(PUBLISHED QUARTERLY)

Journal of the Council for Scientific and Industrial Research.

Vol. I. MAY, 1928. No. 4.

Entomological Research: A General Scheme.

By Dr. R. J. Tillyard, F.R.S., Chief Entomologist to the Council.

Dr. Tillyard has recently furnished the Council with a report on a general scheme of entomological research. The report in question is printed in abbreviated form below. The economic importance of the various problems mentioned has purposely not been enlarged upon in this instance. In a country such as Australia, however, where the main industries are those of a primary nature, the immense damage done by insects is comparatively widely known. It is, perhaps, not so widely known that the only hope of reducing this damage to any appreciable extent lies in the application of fundamental knowledge which, in its turn, will become available only as the result of some such research work as recommended by Dr. Tillyard. It will not be possible for the Council to give immediate effect to all Dr. Tillyard's recommendations as the present shortage of trained entomologists, apart altogether from financial considerations, constitutes a serious difficulty. A commencement, however, has been made, and Dr. Tillyard is now on a visit to Europe and America, where he is arranging for the obtaining of insects and parasites likely to be useful in the attack on Australian entomological problems.—ED.

1. Introduction.
2. Outline of the general scheme of research.
3. Buildings.
4. Personnel and salaries.
5. Training.
6. The Imperial value of the scheme.

1. Introduction.

In considering a general scheme for entomological research to be undertaken by the Commonwealth Council for Scientific and Industrial Research, and to cover the whole of Australia's requirements, two salient features at once stand out:—

(i) The great number and diversity of the entomological problems still unsolved, and the admitted difficulty of many of them.

(ii) The necessity for avoiding, as far as possible, duplication of the economic work already being done by State organizations.

A workable scheme, it appears to me, can only be evolved under these conditions, provided that the scope and aim be narrowed to sharply defined limits, which should have primarily in view the economic solution of the greatest of the outstanding entomological problems along certain definite lines.

With this idea in my mind, I have suggested that the following limitations be recognized for the Council's work:—

(i) All extension and administrative work should be left to the State organizations, except for the small but necessary amount of such work required to keep the Federal Capital Territory itself clean of pests.

(ii) In consequence, the Commonwealth organization will be purely a research organization, and its work on any problem must cease when a practical solution of it has been attained.

(iii) The lines of research undertaken should be mainly those delimited by the broad term "methods of biological control," and will therefore naturally divide themselves into the two following types:—

(*a*) Control of insect pests by beneficial parasites or predators; and

(*b*) Control of noxious weeds by their natural insect enemies.

In order to carry out these ideas effectively, I have recommended that a central research station be built at Canberra, and that certain sub-stations should also be established in various parts of the Commonwealth. The details of these are set forth under the section on "Buildings."

The magnitude and difficulty of the main problems involved make it essential that only the very best type of research men should be employed. My recommendations under this heading are set forth in the section on "Personnel and Salaries."

The annual cost of maintaining the entire scheme, apart from salaries, is considered under the section entitled "Running Expenses."

Bearing in mind the importance of this work from the Empire point of view, and considering more especially the admittedly grave shortage of suitable entomologists throughout the Empire, I have also taken into consideration the problem of "Man-power," and have set out my ideas as to how the present scheme may be utilized to assist the Empire in this respect, in the separate section entitled "Training."

The aspect of the Empire-value of the results aimed at is considered under the section dealing with the Imperial value of the scheme.

2. Outline of the General Scheme of Research.

A.—Classification of the Main Problems.

The following classification of the main problems is offered:—

1. *Biological Control of Noxious Weeds.*

(*a*) Weeds on which no research is being carried out elsewhere. Arranged in the order of relative importance, these are:—

(i) *St. John's Wort.*—This weed has devastated about a quarter of a million acres in the mountainous districts of Eastern Victoria, while smaller infestations occur in the States of New South Wales and South Australia. The worst infestation is in the upper Ovens Valley, where the pest extends almost continuously from the river beds to the tops of the mountains. Control is urgently necessary owing to the weed having crossed the Dividing Range, and begun its descent upon the rich dairying lands of North Gippsland. No satisfactory method of mechanical control is known. Salting the land, which is at present practised to some

extent, kills the weed for two or three years, but it is expensive, and the seeds spring up later with renewed vigour.

The possibilities of biological control of this weed are good, as it has an extensive fauna of insects confined to the genus *Hypericum*, and the genus itself is isolated sufficiently to make it highly improbable that most of these insects would accommodate themselves to other plants of economic importance.

(ii) *Hoary Cress.*—A bad weed, spreading very persistently in parts of Victoria, and resistant to all known methods of control. The root is long and tough, like that of the horse-radish, and every piece of it cut up or ploughed in, grows into a fresh plant.

Biological control will be difficult, but it should be attempted. The plant has a number of near relatives, such as cress, turnip, radish, &c., which are of great economic importance.

(iii) *Saffron Thistle.*—A very serious pest, spreading rapidly over large areas in Victoria and New South Wales. It should be controllable by either an insect destroying the flower-heads, or by a root or stem-borer.

(iv) *The Burrs.*—Sheep-burr, Bathurst burr, and allied species. Genera *Acaena* and *Xanthium*. The prickly seeds cause great losses in deterioration of wool and mutton through catching in the wool of sheep. The seeding of the plants should be controllable through specialized insects attacking the buds, flowers, or seed-heads.

(v) *Stinkwort.*
(vi) *Star thistle.*
(vii) *Paterson's Curse* (Viper's Bugloss).
(viii) *Skeleton Weed.*

(*b*) Weeds which are being studied at the Biological Control Laboratory in Nelson, New Zealand.

The most important of these are blackberry, ragwort, and gorse. All three are pests in parts of Australia. The new organization could work in collaboration with the New Zealand organization by extending their results to Australia, and also might initiate some new mode of attack on these problems by means of insects and fungi combined, as Dr. Dickson, the Council's botanist and mycologist, is keenly interested in this line of research, and has offered to collaborate.

As will be seen under the section "Buildings," it is proposed to go ahead at once with the erection of three closed quarantine insectaries with baffle chambers and quarantine storerooms attached. Each of these is a modification of the design already in use in the Biological Control Station at Nelson, the modifications made being mainly concerned with the difference of climate as between Nelson and Canberra, and the greater likelihood of damage by hail at the latter place.

Two of these insectaries will be available for noxious weed work. It is proposed to start at once with the study of St. John's Wort control.

In connexion with this work, the organization of supplies from other countries is of the greatest importance. At the present time, the supplies of noxious weed insects for the biological control work at Nelson are being obtained from Rothamsted, where a special research worker is retained to work wholly on this problem. Australia's needs may, perhaps, best be met by arranging with the Rothamsted authorities for similar work to be centred there, but it will also be necessary for the workers to range further afield to the Pyrenean and Mediterranean regions, and later also probably to other countries, as it has to be remembered that Australia's weeds have mostly a warm temperate to sub-tropical distribution.

In considering the most promising centre for organizing a supply-base, I have selected tentatively the towns of Montpelier and Toulouse, in the south of France. Both have good universities, with workers in entomology, and both are well placed as regards railway communications. Montpelier is probably the more suitable of the two, and appears to offer somewhat superior railway facilities to those of Toulouse.

2. *Biological Control of Insect Pests.*

(*a*) *Pests of Animals.*

(i) *The Sheep Blowfly Pest.*—This is the outstanding problem in economic entomology for Australia. Estimates of the annual loss due to it run in the region of £3,000,000 to £4,000,000. The problem has been studied in both Queensland and New South Wales, where it is at its worst, by entomologists employed under State Blowfly Committees, but twenty years of intermittent work have yielded little improvement in the situation.

Though admittedly an exceedingly intricate and difficult problem, it seems to me to be one which ought to yield to a solution along the methods of biological control. It is, however, essential that a strong research organization should be built up, consisting of men who can give their whole time to the problem, if success is ever to be attained. This organization must be equally strong, both on the supply side, and on the home research side. The ideal to be aimed at is a thorough search of the whole world for the best possible parasites and predators, and the most careful and complete testing of them in Australia, with a view finally to the liberation, not of all and sundry as received, but only of the very best combination possible.

For the above reasons, the requirements given under the section "Personnel and Salaries" for this research will be found to be double those of any other single line of research.

(ii) *The Buffalo-fly Pest.*—The buffalo-fly pest is a very serious pest of the cattle industry in the North-west and Northern Territory, and is steadily extending its range eastwards towards Queensland. The only hope of controlling it lies in an effective parasite of the larva, which is a cattle-dung feeder.

(*b*) *Pests of Plants.*

(i) *Pests of Orchards and Fruit-crops.*—An immense field for research opens up here. For a start, I have selected only three out of a very large number of problems, viz.:—Apple thrips, the lucerne flea, and the pea mite.

(ii) *Pests of Field-crops and Pastures.*—The outstanding pest at the present time is the grass-grub, which has devastated large areas of good dairying land in Tasmania, and is also a serious pest in parts of Victoria.

One of the three large insectaries will be set aside for investigations on this insect, which is already being studied by Mr. G. F. Hill, Assistant Chief Entomologist to the Council.

(iii) *Pest of Forests.*—With the development of a forward policy in forestry in Australia, the insect pests of forests are becoming of greater importance, and a corresponding forward move in forest entomology is required. It is proposed, for a start, to appoint one forest entomologist to work in collaboration with officers of the Forestry School at Canberra.

The small field station proposed for the Federal Capital Territory will be of special value for the study of forest insects, as the Territory has good forest areas, both of native and introduced trees, in its vicinity.

B. Organization of Research Units.

Apart from junior unskilled workers, who should be appointed from time to time as the progress of the various researches requires, the main organization of the scheme will consist of research teams, each formed by one senior and one assistant entomologist for any given piece of research.

The following is the classification of research units:—

(i) *Noxious Weeds Research.*—One research team. Both senior and assistant should work in Europe during the first European summer. The senior entomologist should return to Australia towards the end of the year 1928 with the first year's supplies of St. John's Wort insects, and should begin at once the testing of these in the insectaries at Canberra, which should be ready by then. The assistant should continue to work from Rothamsted and Montpelier as bases, forwarding supplies for some years for this and other weeds.

(ii) *Sheep Blowfly Problem.*—Two research teams. One of these, called the supply team, would be centred in England and France; the other, called the home team, at Canberra, where a special blowfly research unit will be constructed.

The duties of the supply team will be to study the parasites and predators of blowflies throughout the world, beginning with Southern Europe, and to send supplies of the most promising insects, with full accounts of their life-histories and interactions with other parasites.

The duties of the home team will be to receive the supplies, to rear and test them in the blowfly unit at Canberra or at one of the sub-stations which may later on be available in blowfly-infested areas, and finally to determine, under the guidance of the Chief Entomologist, the exact nature and extent of the attack which should be launched against the pest.

(iii) *Buffalo-fly Problem.*—One research team. The assistant should work in Europe in close association with the blowfly supply team for a year, and later on extend his operations to Egypt, the Soudan, and parts of Africa, India, and Malaya, where the pest occurs. The senior (to be appointed probably six months or a year later) must take charge of the Australian end of the problem, with centre at Canberra in the summer, and probably in the North-west during the winter.

(iv) *Orchard and Fruit Pests.*—One research team. The assistant should begin work in Europe on apple thrips and lucerne flea; the senior to be appointed somewhat later for work at the Australian end.

(v) *Field-crop and Pasture Pests.*—One research team, of which the senior entomologist will be Mr. G. F. Hill, Assistant Chief Entomologist to the Council. One insectary at Canberra is set aside for the important work on the grass-grub which Mr. Hill already has in hand. An assistant will be needed later, to work in Europe and elsewhere.

(vi) *Forestry Problems.*—One forest entomologist, to work in collaboration with the officers of the Forestry School at Canberra. The grading of this officer might perhaps be intermediate between that of senior and assistant as regards salary, and he should also be officially in charge of the field laboratory in the Federal Capital Territory.

(vii) *Organization of Research Facilities at the Central Research Station.*—For the general purposes of research at Canberra, a strong organization to cover extensive collections, library, and technical appliances is required.

For this there will be required the services of a senior entomologist and curator, who should have charge of all the collections, museum, technical appliances, &c.; a librarian, who should preferably also be an entomologist and a good linguist; and an expert photographer to take charge of the photographic work, studio, and dark rooms.

The above senior entomologist and curator will, in many respects be the most important officer at the central station, and should be selected most carefully. We need a man of high entomological and technical ability, who can place his expert services at the disposal of every research officer, and who can bring the museum and collections to a high state of efficiency and usefulness.

The senior entomologist and curator should be appointed by the beginning of 1929, the others perhaps later, according to the progress made with the buildings.

(viii) *Secretariat at Central Research Station.*—A secretary and typistes will be required at the central research station. Finance and accountancy will be dealt with from the Council offices in Melbourne.

(ix) *Upkeep of Building and Grounds.*—For a start, it will probably suffice to have a married couple, living in a caretaker's cottage, to undertake the duties of gardener, caretaker, and cleaner combined.

The classified list of staff appointments recommended as above is shown under the section "Personnel and Salaries."

3. Buildings.

The buildings required may be divided into two groups, as follows:—

A. Central Entomological Research Station, Canberra, F.C.T.

B. Sub-stations.

The total estimated cost of the above is £50,000, allocated as follows:—A., £38,000; B., £12,000.

A. Central Research Station, Canberra.

In view of the urgency of the case, it is essential that the design of the central research station should be such that a portion of it can be built in a comparatively short time as an efficient research unit, leaving the completion of the building to be gone on with after the actual researches have begun.

The design recommended consists of a central large two-story block, which would contain the secretariat, offices, library, museum, lecture-room, &c., together with the rooms of the chief and assistant chief entomologists; and either one or two one-story side-blocks containing the research rooms, general laboratories, &c., and connected with the insectaries at the back. A special blow-fly unit is allowed for, well away from the main building, and provision is also made for garage, caretaker's cottage, &c. The central block, with its necessary equipment, would probably cost £28,000 to erect.

It is estimated that the cost of the insectaries, blowfly unit, caretaker's cottage, &c., would be in the region of £10,000, so that the total capital cost of the Canberra establishment would be £38,000.

B. Sub-Stations.

Field stations should be established in the Federal Capital Territory, in Western Australia, and in Tasmania. The field station in the Federal Capital Territory is required urgently for the purposes of field and forest entomology, and more especially for the intensive training of the whole staff, which forms part of the general policy, as indicated under the section on "Training." The other two sub-stations are needed owing to the isolation of the States concerned. The total capital cost of these three sub-stations will be about £12,000.

4. Personnel and Salaries: Running Expenses.

Considering these two together, it appeared advisable that a fixed annual sum (£20,000) should be allocated for the two, and that, as the work progressed, the running expenses (which would include, at

first, the purchase of a great deal of permanent equipment) could be made to decrease at the same rate as the salaries increased. From the year 1929 onwards, for a period of five years, estimates of (*a*) salaries, and (*b*) running expenses, could be made according to the attached table. For the broken year 1928, there would be comparatively small cost on account of salaries, as only a few of the officers would be appointed, and those only for parts of the year; but, on the other hand, there would be certain special large payments to be made on account of purchases for equipment, books, &c., and also considerable amounts on travelling.

For a complete year, the estimated total expenditure would be £20,000, of which salaries would take £12,450 in 1929, rising to a possible £14,800 in 1933, which would be the maximum. This would only be reached provided that all officers retained their posts for five years. The balance, viz., £7,550 in 1929, ranging down to £5,200 in 1933, would be available for the annual running expenses, which must include all travelling costs, wages of temporary and junior employees, additions to equipment, &c., &c.

5. Training.

One of the peculiarities of economic entomology is that the actual field work has its periods of intense activity and of slackness. These, of course, correspond, in a temperate climate, with the summer and winter seasons. In Australia, they are complicated by the fact that the periods of activity of insect life are more or less correlated with the very irregular periods of rainfall. Consequently, any man engaged on an economic entomological problem may find himself faced with a slack period, not only during winter, but also during periods of drought.

During the whole of my entomological research training in Australia, I solved this problem by always having on hand certain subsidiary studies designed to increase my research capacity, and to keep me fully employed whatever the field conditions might be like. Later, when I undertook the organization of entomological research at the Cawthron Institute, Nelson, New Zealand, I instituted a system based on the same idea. The effect of this system is that every research man continues to be, in a subsidiary measure, a student as well, and, while carrying on his main line of research with unabated vigour, he has his interests widened and stimulated by lectures and demonstrations arranged from time to time during the slack periods, and is also required to advance in his knowledge of general entomology by taking a special interest in some selected group of insects.

It follows that the organization is also suited for the reception of research students from abroad, who can be made to fit into and assist with the general scheme of research and at the same time receive an intensive training of a post-graduate type.

The scheme, when completed, should allow of the reception of ten post-graduate research students from abroad, who can undergo either one-year or two-year periods of training at the central research station. Each student would be expected to select—

(*a*) Some problem in connexion with one of the main lines of research being undertaken by the research teams.

(*b*) Some problem connected with the selected group of insects in which he desires to obtain expert knowledge.

Problem (*a*) is to take precedence of problem (*b*), which is only to be worked at during the slack periods of problem (*a*).

For the research teams, the same idea is encouraged. Problem (*a*) represents the main research work on which they are engaged; but, during slack periods, when this work cannot be gone on with, each man must select a problem (*b*) connected with one group of insects, which will put him in close working touch with the museum and library, and keep him interested in the general advance of entomological knowledge.

The final result of this is that there emerge from the research teams not only experts in the special problems studied, but also experts on the various main groups of insects, whose special knowledge of each group studied is then available to all.

In suggesting and directing the group studies, the Chief Entomologist has in mind the perfecting of an organization holding expert knowledge of all the major groups of Australian insects, so that whatever problems the future may disclose, the necessary experts may not be lacking.

6. The Imperial Value of the Scheme.

In stressing the Imperial value of the above scheme, it is necessary to emphasize the facts that Australia not only presents economic entomological problems of outstanding difficulty, but that it also possesses an insect fauna probably of greater general interest from all points of view than any other in the world. The combination of research work on the two offers an unique opportunity for the training of Empire entomologists. The solution of many of the main problems now to be studied will also be of great value to other parts of the Empire; for instance, the noxious weeds work, if it succeeds, will initiate a method of general application to other infested parts of the Empire; the blow-fly work is of importance to New Zealand and South Africa, as well as Australia; the grass-grub work to New Zealand, and so on. Also, Australia's entomological problems range from those of the tropics to those of temperate Tasmania, and thus touch those of India on the one hand, and England on the other. Probably in no other part of the Empire does an equally good opportunity exist for obtaining so wide and varied an experience in research in the leading problems of economic entomology.

The Australian Forestry School.

By C. E. Lane-Poole, Acting Principal.

1. General.

The Australian Forestry School has been founded for the purpose of giving higher forestry training to the staffs of the Forestry Departments of the six States of the Commonwealth. It is proposed that the school shall be a branch of a Commonwealth Forestry Bureau, a Bill for the creation of such a Bureau having recently been introduced in Parliament. It is intended that there shall be four main branches of the Bureau, viz., (*a*) Education, (*b*) Research, (*c*) Territorial Forests, and (*d*) Co-operation with the States.

The proposal to establish an Australian Forestry School dates from 1911, when a conference of State foresters suggested that one school to impart higher forestry training to the young men entering the various State services was desirable. At subsequent Interstate Forestry Conferences the matter was discussed and brought up to the point where complete unanimity was reached between the Forestry heads as to site and the division of expenditure between the States. The site chosen was at Laurel Hill, in the New South Wales highlands, some 60 miles south-west of Canberra. The Premiers' Conference then took the matter up, and the Commonwealth Government agreed to bear one-sixth of the cost, and the States to pay the remainder, the amount payable by each State to be computed according to its relative population. A committee was appointed to go into the details, and all seemed as though the school would be established; this was seven years ago. Unfortunately, differences of opinion arose among some of the States as to the location of the school. As a result no further progress was made until 1925, when Senator the Right Hon. Sir George F. Pearce, P.C., K.C.V.O. (then Minister for Home and Territories), approached the States with an offer that the Commonwealth Government would build, equip, staff, and maintain the school if the States would send the students. All the States except South Australia accepted the offer, and the school was started in March, 1926. At first, as buildings were not available at Canberra, advantage was taken of the offer of the University of Adelaide to have the school at that institution. The principal appointed at Adelaide was Professor Norman Jolly, M.A., Dip.For.Oxon., and under his able leadership a standard of education was established which it is hoped to maintain. He was, at the end of the year 1926, appointed to the Chief Commissionership of Forests of New South Wales, and the writer was then appointed in an acting capacity pending the appointment of a principal.

In April, 1927, the building at Canberra was opened for students, and the first academic year of the school on the permanent site (a special area at Westridge, 3 miles west of Canberra) has now closed. The staff consists of the following:—

Acting Principal.—C. E. Lane-Poole, Dip.For. Nancy.

Lecturers—

C. E. Carter, B.Sc. (Agric.), M.F. (Yale).
H. R. Gray, M.A., Dip.For.Oxon.
A. Rule, M.A., B.Sc.(For.).

2. Work of the School.

The school provides a two-years' course in pure forestry, at the end of which successful students are awarded the Commonwealth Forestry Diploma. Applicants for entrance to the course must be graduates of an Australian University or matriculated students who have had a minimum University course of two years in science. It is recognized that a course of two years in pure forestry can be sufficient only if students have previously received a thorough grounding in sciences allied to forestry.

The object of the course is the training of professional foresters for the Federal and State Forest Services, and of men to carry out independent investigations in the various phases of scientific forestry and allied sciences. The training of forestry research workers is a need no less pressing than the training of professional foresters. In this respect, the school is particularly fortunate in that it will be in a position to co-operate with the Forestry Research side of the proposed Bureau in carrying out the investigation of problems of sylviculture and forest management, and with the proposed Forest Products Laboratory in the study of problems connected with the utilization of forest products.

Field training occupies a very important position in the work of the course, and from this point of view it was essential to establish the school on a site which offered sufficient scope in this direction. There are in the immediate precincts a fine coniferous arboretum and an extensive nursery, which supplies planting stock for the whole of the Federal Territory. Within easy reach there is an extensive range of forest types, including firewood reserves, established coniferous plantations, and areas of mountain forest ranging from 2,000 to 4,000 feet elevation. The preparation of a working plan for each of the above types forms part of each student's work for the course. Collection of field data for the working plan embraces the survey and subdivision of the forest areas, assessment of soil and timber, establishment, and periodic measurement of sample plots for increment data. Thinnings, general tending operations, afforestation (planting), and regeneration operations generally also come within the scope of field training in sylviculture and forest management. The forest areas are visited weekly, and, in addition, camps are established during the short and long vacations, so as to give students every opportunity of tackling in the field concrete problems of sylviculture and forest management, while putting into practical application the knowledge gained from their studies.

The building itself, both as regards site and dignity of architectural design, may well challenge comparison with any others in Australia's capital. In the interior construction, Australian timbers have been used throughout, and the handsome effect obtained should provide a most salutary object lesson to a public mind, which is obsessed with the idea that only exotic timbers are suitable for building construction. Here there is concrete evidence that, given proper discrimination in the selection of Australian timbers for specific uses and adequate seasoning methods, the widespread prejudice against the use of our natural timbers is distinctly unjustifiable.

Of a compact rectangular shape, the building contains a spacious museum, library, two lecture rooms capable of seating 50 students, well-equipped laboratory, drafting room, and rooms for the principal, lecturers, and typiste.

In the museum, in addition to an extensive herbarium of Australian timber species and an entomological collection, a range of the commercial woods of the world is being gradually built up. This provides excellent demonstration material in conjunction with lectures, and, as time goes on, it is intended to house in the museum collections dealing with the utilization of forest products.

The school has established contact with all the leading educational institutions in the world dealing with forestry or allied sciences, with the result that it has already succeeded in building up a wide range of forestry literature.

The subjects taught include forest botany, sylviculture, forest management (including mensuration, valuation, forest policy and economics), forestry protection (including fire control, forest mycology, and forest entomology), and forest utilization.

During the two years in which the school has been established fourteen students have completed the work of the course. In addition to fresh nominees sent forward by the States in accordance with the annual programme, there are four research scholarships, applications for which have been called by the Commonwealth Government.

3. Forestry Research.

As already stated, it is proposed that the Forestry School shall be one branch of a Commonwealth Forestry Bureau, and that the three other branches of the Bureau shall be—Research, Territorial Forests, and Co-operation with the States.

As regards research work, it is proposed to initiate investigations into the three main divisions of forestry—sylviculture, management, and protection. Sylviculture covers all the ecological side of the subject, and means the study of not only each timber species from seed to sawdust, but its behaviour in different sites, its re-actions to different environmental conditions of climate, soil, and vegetation. Management is based on sylviculture, and, as its name implies, covers all the methods under which a forest can be worked to supply a sustained yield of timber for the needs of a population. Until recently, the only system of management in Australia was selection by the saw-miller and timber-getter of the trees they wanted. Then comes protection. This branch covers all the enemies of the forest—man and his firestick, beast, bird, insect, and fungous disease, damage by wind and, in our highlands, by frost and snow. In this division would also fall the study of the beneficent effect of forests as barriers to wind and water erosion, and as conservers of water in the mountain regions and equalizers of climate.

Up to the present very little has been done in Australia in connexion with forestry research, and that little has been mainly on the systematic botanical side. Valuable as it is, it has not been carried far enough, and so hardly touches the sylvicultural division. It must not be thought from this that I am entirely in agreement with the late Sir

David Hutchins,* who wrote that forestry and botany have as little connexion as zoology and horse-racing. A thorough knowledge of the botanical identity of the whole forest vegetation is indispensable to the sylviculturalist. He must know the names of his trees and plants. Apart from Diel's work on the vegetation of Western Australia, and C. T. White's *Forest Botany of New South Wales,* botanists have not gone much further than to describe species and name them. It is for foresters to continue the research, and that they have not done so is due to the small number of trained men in the various Departments, and the fact that the handful of qualified foresters find their time wholly occupied in administrative and general executive functions. The resolution of the Perth meeting of the Australasian Association for the Advancement of Science, urging the Commonwealth Government to establish an organization to carry out the much-needed research work into sylviculture and management, will be given effect to by the Research Branch of the Commonwealth Forestry Bureau, and, in order to obtain recruits for the work, applications for four scholarships from honours men in science have been called for. These men, after a course at the Forestry School, will go abroad for two years to read up and study the particular branches for which they are most fitted.

On the protection side, more work has been done, and particularly is this the case where insect attacks are concerned. Froggatt and French have both studied the life histories of a number of insect enemies and friends of the forest. There is still all the work to be done in regard to the prevention and suppression of the noxious insects. In the matter of fire prevention, control, and suppression, the field is a wide one. In mycology, Cleland and others have done fine work. There yet remains the work of co-ordinating the results and applying preventive measures. The alteration of conditions following the denudation of mountain sides in the good rainfall areas, and the formation of desert conditions inland, through the same cause, both need investigation.

The Research Branch of the Bureau is directed at the living forest as opposed to the dead products derived from the forest. The latter are subjects for research by the Forest Products Laboratory, a proposed branch of the Commonwealth Council for Scientific and Industrial Research, with which institution the Bureau will maintain a close liaison.

4. Territorial Forests.

The third branch of the Bureau—territorial forests—covers all the forests of the Federal territories. These territories extend over an area of 432,000,000 acres, and, except for the Territory of the Seat of Government, none has, as yet, embraced a forest policy. The Federal Capital Commission has already established a Forests Department and appointed a qualified staff. It is anticipated that when the Forestry Bill becomes law similar steps will be taken by the Administration of New Guinea and of Papua.

5. Co-operation with the States.

The last branch of the proposed Bureau covers co-operation with the States. The extent to which this co-operation between the Commonwealth and the States can go is very great. The destruction of

* *A Discussion of Australian Forestry.* Government Printer, Western Australia.

forests in the past has been calamitous, the need for re-forestation is most pressing, and the State Treasurers find it harder and harder to set aside money from their resources to meet what many regard as a national, rather than a parochial, matter.

From what has been written it will be seen that the Bureau has already functioned in a restricted manner in most directions that form its natural functions, but in none has it progressed as fully as it would like, and this is true even of the Australian Forestry School.

6. Conclusion.

The question of forestry education generally is one which is of particular interest to Australia, with its forest estate of 24,500,000 acres. A forest area of this size, if it is to be handled on lines at all approaching scientific management, requires a large staff of highly trained foresters. Such men cannot be imported from overseas at a moment's notice, and it would, in many cases, be a grave reflection on Australia if she could not train foresters capable of tackling her own forest problems.

From the very fact that the growing of a timber crop is spread over a long period of years, forestry has certain aspects entirely peculiar to itself which render the demand for trained men in this profession all the more insistent. Agriculture may be cited broadly as a parallel, but whereas empirical methods may produce a farmer at the cost of one or two lean years, the same methods applied to forestry, unless backed by previous experience and training, must result, not only in costly failures, but also in wasting many valuable years.

The forestry problem in Australia, where no crop of eucalypts has been grown through a whole rotation—from the seedling stage to commercial maturity—is by no means an easy one, even for the trained forester. Nature's efforts have only, in too many cases, been sadly distorted through the devastation of repeated bush fires, which have resulted, not only in malformed growth, but in the entire alteration of forest conditions generally. Reckless overcutting by man, with no attempt at replacement, has resulted in further aggravating conditions already abnormal. Again, in the introduction of exotic conifers there are in Australia no established coniferous plantations of sufficient age to be a safe guide to the forester in his selection of species for different climatic ranges and soil types. Sound training and experience alone can fit a forester to tackle problems such as these.

To imitate nature and to hasten her work is, as has been well stated by a famous French forester, the fundamental maxim of sylviculture. Scientific forestry training is based primarily on a close observance of nature's laws, and these are revealed both from a study of the fundamental sciences and from the accumulated experience built up by long years of forestry practice and trained observation in the older countries of the world. The object of any forestry course is not to turn out adepts in standardized systems of management, but to turn out trained thinkers, who, by their grasp of the fundamental principles underlying such systems, can render them plastic and mould them to the requirements of the particular forest type with which they have to deal.

One aspect of professional training which is generally overlooked is that it tends to inculcate a spirit of pride in one's profession. Professional *esprit de corps* must be regarded as no mean asset in the equipment of any trained man. Indeed, the most real benefit of training in

forestry, as in any profession, may be said to become most apparent when the problem confronting the forester is such that it demands all his courage, and a firm conviction in the highest ideals of his profession, to prevent him getting utterly disheartened and following the line of least resistance.

To say that such a job awaits the professional forester in Australia to-day is no exaggeration. He is faced with the problem of regenerating timber areas depleted to the verge of exhaustion, and it will take all his professional *esprit de corps* to prevent him losing heart in his job. Public opinion is notoriously shortsighted in anything that pertains to the welfare of posterity, and only trained men can be trusted to pursue an undeviating course in tackling Australia's forest problems. The Forestry School in this direction will try to supply a very real and pressing need in Australian forestry, and inculcate in its students the underlying spirit of the motto blazoned above its doors *Mihi Cura Futuri.*

Dairy Research—Tentative Proposals.

By Professor A. E. V. Richardson, Director, Waite Agricultural Research Institute, University of Adelaide.

The following memorandum on dairy research was prepared by Professor A. E. V. Richardson—a member of the Executive Committee of the Council—for submission to the meeting of the Standing Committee on Agriculture, held on 7th of March, 1928. The whole question of dairy research was discussed at that meeting by the permanent Heads of the State Departments of Agriculture (with the exception of the Western Australian Department); by representatives of the Council, of the Australian Dairy Council, and of the Dairy Produce Control Board; and by the Commonwealth Supervisor of Dairy Exports. It was formally resolved:—

"That this Committee is in accordance with the suggestion that the Council for Scientific and Industrial Research should undertake research on problems affecting the dairying industry. It is considered that not more than one bacteriologist and one chemist would be required in the immediate future."—Ed.

1. General.
2. Summary of information submitted to C.S.I.R.
3. Policy of the Council.
4. Scientific problems in dairying which appear to require attention.
5. Organization for research in dairying.

I. General.

The Council for Scientific and Industrial Research has experienced considerable difficulty in initiating a programme of research on dairying problems. It is aware of the great importance of the dairying industry to the national welfare, and realizes that the application of scientific knowledge to the industry must inevitably lead to a material increase in production. The difficulty, however, has been to reconcile the conflicting views hitherto held as to the part which the Commonwealth Council might take in any organized scheme of dairy research. The State Departments of Agriculture have strong well-organized dairying divisions, and these, together with the dairying companies, have been largely responsible for the advances that have been effected during recent

years, both on the production and manufacturing sides of the dairying industry. The State Departments of Agriculture generally hold the view that the outstanding needs of the industry at the present juncture lie in the direction of the application of known scientific principles to production, rather than in the discovery of new knowledge through research.

In January, 1927, the State Committees of the Council were requested by the Executive Committee to advise it as to the desirability of the Council undertaking investigations on dairy problems. The matter was discussed at a meeting of the full Council, but no definite action was taken in view of the great differences of opinion as to what should be done existing among the States and the authorities concerned.

2. Summary of Information.

The following statement gives a brief summary of the information submitted to the Council on dairying problems:—

(1) At an early stage of the inquiries the State Departments of Agriculture had been asked as to their attitude towards the use of boric acid, and the replies received indicated that there was a considerable difference of opinion among them as to the necessity or otherwise for its use, and that any experiments to develop a substitute would not be favorably regarded by all.

(2) On the 6th April, 1921, Mr. O'Callaghan, the then Commonwealth Dairy Expert, recommended that the Institute of Science and Industry should—

- (*a*) Detail a biochemist for the purpose of conducting research work in dairying; and
- (*b*) Establish laboratories where research work should be carried out.

(3) On the 23rd July, 1926, Mr. P. J. Carroll, Commonwealth Supervisor of Dairy Exports, drew attention to the faults and defects of butter and cheese, which do not respond to the efforts of ordinary dairy instruction. He recommended that a dairy bacteriologist should be appointed to investigate such problems. He also drew attention to the wide and important field for investigation relating to the neutralization and pasteurization of cream, and the use of lactic acid starters. This field had opened up as a result of the prohibition of boric acid. He also indicated several other minor matters, such as flavours, requiring investigation.

(4) In a report furnished by Mr. L. T. McInnes on 1st December, 1926, stress was laid on the necessity of applying science to practice in a complete scheme, embracing inspection, instruction, general administration, and research work. Research work should be decentralized as follows:—

- (*a*) The factory unit.
- (*b*) The district laboratory.
- (*c*) The State headquarters laboratory.
- (*d*) The Commonwealth.

The work of (*a*), (*b*), and (*c*) should be controlled by the State and linked up with (*d*). Mr. McInnes's further suggestions were that the Council could assist the States' efforts in respect to (*a*), (*b*), and (*c*),

by money grants, the money to be expended by the State in making additional staff appointments, and in establishing district laboratories, of which some nine to twelve would be required in New South Wales. He recommended that research work be carried out under two headings—

(*a*) Existing conditions and their improvement; and

(*b*) Fresh researches in regard to production, raw material, manufacture, marketing, and transport.

(5) The Council convened a committee consisting of the dairy experts of New South Wales and Victoria (Messrs. McInnes, Archer, and Crowe), the Commonwealth Supervisor of Exports (Mr. P. J. Carroll), Dr. W. J. Young (Associate-Professor of Biochemistry, of Melbourne University), and Mr. H. A. Albiston (in charge of the milk investigational work, Melbourne Veterinary School), to consider the whole question of dairy research.

There were very considerable differences of opinion between members of the Committee from the different States as to the question of preservatives in butter and other milk products, but the Committee was in agreement that work was required on the cause of undesirable flavours in butter and milk products, and the investigation of the more recent hydrogen ion indicators.

(6) Sir Frank Heath, who stressed the importance of the establishment of a Dairy Research Institute in his report to the Federal Government on the organization of the Council (Council for Scientific and Industrial Research), was asked to amplify his reasons. He quoted extensively from the fourth report of the Imperial Economic Committee, in which it is stated that the more important problems of research in connexion with dairying may be grouped under the following headings:—

(1) Methods of improved production.

(2) Food values including vitamines.

(3) Utilization of milk residues.

(4) Refrigeration.

(5) Economic research.

Sir Frank Heath stated that he was inclined to put more stress on the value of research into milk residues than does the report of the Imperial Economic Committee, and he emphasized the importance of work on the chemistry of casein and its possible industrial applications He advocated the initiation of dairy research, mainly because of the rapid development of the industry and because less investigational work had been carried on in dairying than in the other important primary industries.

(7) At the Agricultural Conference convened by the Council in March, 1927, the respective spheres of the Commonwealth and the States in regard to agricultural research, were defined in general terms. The Conference affirmed that the problems which were more or less fundamental in character, and national or regional in scope, should be conducted by the Commonwealth, whilst problems of a more or less local character, and which involve the application of existing knowledge, should be undertaken by the State Departments of Agriculture.

(8) At the meeting of the Standing Committee on Agriculture, held in Adelaide in May, 1927, Professor Rivett stated that the Council

had made extensive inquiries regarding dairy research, but that the weight of evidence seemed to indicate that the present troubles with the industry were due primarily to a lack of application of existing information rather than to a lack of knowledge. Messrs. Ross (New South Wales), Graham (Queensland), Perkins (South Australia), and Sutton (Western Australia) expressed themselves in agreement with these views. The Chairman, Dr. Cameron (Victoria), remarked that unless the present Standing Committee suggested definite subjects for research, the Council would take no action. No such proposals were made.

(9) The Australian Dairy Council, in a resolution in October, 1927, stated that there was an urgent need for a Research Institute in Australia, to be devoted solely to the investigation of problems connected with the manufacture of dairy products. The precise nature of the problems which should be investigated was not, however, submitted by the Dairy Council.

3. Policy of the Council for Scientific and Industrial Research.

The Council desires to work in the closest co-operation and collaboration with State institutions in research work, to avoid any unnecessary duplication or overlapping of work, and to investigate problems of regional rather than of local interest. It is especially desirous of following this policy in respect to dairy research in which the State Departments of Agriculture and the dairy companies have already such considerable interests. It therefore proposes to bring the question of dairy research before the Standing Committee of Agriculture—which includes the Directors of Agriculture of each State—in the hope that a clear understanding might be arrived at as to the respective spheres of the Commonwealth Council and the State Departments of Agriculture in regard to dairy research. In order to provide a basis for discussion, it is proposed to set out tentatively some of the more important scientific problems which appear to require attention.

4. Scientific Problems in Dairying which appear to require Attention.

1. *Comparison of Australian Conditions with Overseas Countries.*

The climatic and economic conditions under which dairying is carried out in Australia, differ very materially from those prevailing in Europe, the United States, and Canada. It is necessary to stress these differences in dairying practice when comparing the needs of dairy research in Australia with those of other countries.

The more important contrasts between European countries and Australia are as follows:—

(1) The climatic conditions of Australia are so favorable as to dispense with the necessity of housing stock. Much less feed has to be saved in summer to provide for the winter months than in other competitive countries.

(2) Dairying production in Australia is pre-eminently seasonal. Generally speaking, no attempt is made to maintain production through the winter months, since this would involve additional tillage and conservation of fodder, and use of concentrated foods, and would increase the cost of production. A more continuous supply of dairy products could, no doubt, be brought about, but the change would need to be gradual.

(3) The pastures of the country form the main, and almost the exclusive, source of food for dairy cattle. Forage crops are used as supplements to the pastures in some instances. In this respect, Australian dairy practice is in marked contrast to that prevailing in Europe, where extensive use is made of fodder crops and concentrated foodstuffs for feeding stock.

(4) According to the *Commonwealth Year-Book* for 1927, the total Australian production of milk for the year 1926 was 773 million gallons, of which 587,000,000 gallons were used for the manufacture of butter, 27,000,000 gallons for cheese, 20,000,000 gallons for concentrated and condensed milk, and 138,000,000 gallons for other purposes.

It is clear, therefore, that the problems associated with the production of milk and the manufacture of butter are of outstanding importance to Australia.

(5) The main manufactured product is butter, as nearly 80 per cent. of the total milk produced is so used. In this respect, Australia differs markedly from Britain, where some 75 per cent. of the milk produced on the dairy farms is sold as milk. It is necessary to emphasize this point, because the Dairy Research Institute in Britain has concentrated largely on the investigation of problems relating to the production and transport of milk, and those relating to a pure milk supply.

(6) A further point of contrast between the problems affecting butter production in Europe and Australia needs emphasis. In Europe, butter is subject to relatively short haulage and rapid consumption. Export butter from Australia involves long haulage and deferred consumption. The practices found suitable for Europe in regard to manufacture of butter may therefore not necessarily be suitable for Australian conditions.

It would therefore appear that, in view of wide differences in climate, economic conditions, and food supply for dairy cattle in Australia as compared with other competitive countries, it may be necessary to repeat some European work to see how far the principles established elsewhere are applicable to the special conditions of the dairy industry of Australia.

It is necessary to stress this point because it is unsafe to rely absolutely on results obtained in other countries with widely different conditions and climates. Hence the results of work done elsewhere may have to be repeated here to determine how far the work is applicable to local conditions. It may be added that an industry that relies solely on the scientific work of other countries cannot hope to occupy permanently a commanding position in the world's market.

2. *The Scientific Problems relating to Dairying.*

The scientific problems relating to dairying may be arranged in three groups—

(1) Production.
(2) The manufacture of dairy products.
(3) The economic aspects of dairying.

(1) Production.—The average annual production of milk from cows of the Commonwealth is 340 gallons per cow. This is not a high average compared with production in other countries, notably Denmark and Great Britain The raising of the average yield per cow is one of

the main objectives of the dairy divisions of each State Department of Agriculture. Vigorous efforts are being made to stimulate the interest of the dairy farmers in herd testing. The use of systematic herd testing and of pure bred bulls has been strongly advocated by all Departments of Agriculture, and the results of herd testing in all States show how the standard of production in individual herds may be greatly augmented by these methods. The increase of production by these methods is largely a matter of propaganda, as the principles are well known, and ample evidence of the soundness of the methods advocated is available from local sources.

Improved methods of feeding will lead to an increase in the average milk yield, but here again the major facts are well known to all dairy departments, and the improvement in feeding methods appears to be largely a matter of propaganda and economics. There are, however, certain aspects of the nutritional problem which might be investigated.

(*a*) *Nutrition.*

(i) *Comparison of Rations and Economic Use of Concentrates.*—Concentrated foodstuffs are used only to an insignificant extent in Australia, in comparison with other countries. At the same time, it must be remembered that, in most other dairying countries, cows cannot be depastured throughout the year, as is the practice in Australia. The field of feeding may require review in order to correlate grazing conditions with feeding standards, and to determine the place, if any, of concentrated foodstuffs in feeding practice. The investigation of the economic use of concentrates in supplementing a grazing ration could be carried out in State-owned herds at Government farms.

This aspect of the nutritional problem would appear to be largely a matter for local investigation by State Departments of Agriculture.

(ii) *Top-dressing of Pastures.*—The top-dressing of pastures with soluble phosphates is becoming increasingly popular, especially in Victoria, New South Wales, South Australia, Western Australia, and Tasmania. This practice appears to be essential for profitable production. It greatly increases the bulk of herbage, and materially affects the composition of the pasture, especially in so far as it greatly stimulates the growth and development of clovers and trefoils.

This effect of the top-dressing on the composition of the milk and texture and flavour of the produce might be investigated. It has been stated that the top-dressing of pasture lands with superphosphate in New Zealand is affecting the manufacture of cheese.

(*b*) *Bacteriology of Milk.*

(i) Although other countries have made a detailed examination of milk and cream bacteria. a systematic study and analysis of the types occurring in milk from various centres would form a basis for future investigations. This might be done in conjunction with public health authorities, and data so obtained on original contamination, the effect of transport under our climatic conditions, and the effect of pasteurization as at present practised. Such data might serve as a basis for improving city milk supplies.

The bacteriology of milk and cream appears to offer a promising field for research.

(ii) The bacteriological condition of raw milk and cream, prior to its processing, would suggest control methods which might be effectively applied to climatic defects found at a later stage of processing.

(iii) The effect of the by-products of common contaminating bacteria on the nutritional value of milk, and the influence of pasteurization on the products of bacterial fermentation in milk, have not yet been fully worked out. Perhaps too much reliance is placed upon pasteurization to correct defects, for though noxious bacteria may be largely destroyed by pasteurization, their products remain in the milk and cream, and may conceivably affect the quality of the manufactured article.

(iv) Although the methylene blue reductive test is widely used, it has not proved as useful as expected. Information on the reducing power of individual organisms is needed, and the test accepted or rejected authoritatively. The literature on it is not by any means in support. Microscopic examination of milk is not applicable to pasteurized products, and is not selective. Cooledge's test with bromthymol blue only takes account of acidity. If a fairly quick reliable test could be devised, or if the existing tests could be authoritatively approved, it would be a big step forward.

(2) MANUFACTURE OF DAIRY PRODUCTS.—In the manufacture of butter and cheese, bacteria fill an important function. The aroma and taste of butter, and the flavour and ripening of cheese, are largely the result of bacterial action. Many of the problems in dairying find a solution in the application of two important principles—

(i) Deterioration in milk and dairy products is largely due to putrefactive bacteria, and by avoiding common sources of contamination, defects in milk and manufactured dairy products may be eliminated.

(ii) Controlled fermentation in milk and cream is made possible by pasteurization and the use of pure culture starters.

The most pressing scientific problems associated with the manufacture of dairy products concern the bacteriologist and the biochemist.

(*a*) *Dairy Bacteriology.*

(i) *Starters.*—The use of selected lactic ferments in butter-making and cheese-making is now a common practice. The "starter" problem appears to be very important. The use of pure and mixed cultures of desirable bacteria, together with the possibility of selecting a sound aroma producing organism, should be investigated. Authoritative evidence is wanted on the use of starter versus spontaneous ripening of cream, a comparison of both over-long transport periods with butter during export, and a comparison of the final effect of pasteurization with both methods.

Loss of vigour with starters appears to be a common experience. The best conditions for the manufacture of starters, and the most suitable temperatures for maturing them to conserve desirable flavours, need to be determined.

(ii) *Pasteurization.*—A study of the effect of pasteurization on individual organisms in pure culture or mixtures of pure cultures, dealing with large and small infections is desirable. The heat resistance

of specific types to pasteurizing temperatures might be carried through to show the rate of recovery of residue, under normal holding conditions and under optimum conditions.

(iii) *Flora of Export Butter.*—A detailed study of the common flora of export butter, with particular attention to the degree of recurrence of types observed to cause troubles, would give valuable information. An arrangement for bacterial analysis of butters, dropping say two or more points in grading during export to the United Kingdom, would be useful if results obtained here before shipping and from England after arrival, could be compared.

(iv) *Defects in Butter* (e.g., discoloration in butter, foreign flavours, bitter flavour with age). The dairy experts of the State Departments and the Commonwealth Supervisor of Exports appear to attach much importance to foreign flavours in butter. These may arise from bacterial action or from the nutritional factor. In investigations on flavour, reference should be made to the food supply of the animal as well as to the bacterial flora of the manufactured product, i.e., to the influence of pasture plants, concentrated foods, or foods altered by bacterial action, e.g., silage. Concerted opinions of dairy experts might be obtained to narrow down butter troubles to three or four major defects of more than local importance.

(v) *Acidity in Cream.*—There appears to be need for definite information relating to the most desirable acidity in cream to obtain the maximum quality consistent with keeping quality.

(vi) *Pasteurization Problems.*—Pasteurization of cheese milk, and use of starter, although commonly done, is not yet on a sound basis. Manufacuring and curing difficulties might be looked into, in the laboratory and the factory. Pasteurizing temperatures or methods, and curing practice, may be improved on research.

(*b*) *Dairy Chemistry.*

There are many problems involving a knowledge of the technique of dairy chemistry and biochemistry, which would be worked out in collaboration with the bacteriologist. Some of the more important of these are indicated:—

(i) The maximum content of impurities (inorganic) in factory water supplies for manufacturing purposes, and the constitution of such impurities.

(ii) The physical and chemical changes induced in milk and cream pasteurization.

As much of the city milk supply is pasteurized, such an investigation would have a special bearing on human nutrition apart from its value to the manufacture of dairy products. Large scale experiments by the New York Department of Public Health have established the fact that milk held at 140 deg. F. for thirty minutes destroys the tubercle bacilli and other disease-producing organisms.

Most of the conclusions regarding pasteurization have been based on experiments with milk treated by the holding or the flash process. A study of the changes induced in milk by pasteurization is especially important for cheese-making, because coagulation in the cheese vat after heating and curing is unsatisfactory.

(iii) The comparative effects of a single and double pasteurization at a varying range of temperature, more particularly with cream.

(iv) The seasonal growth of the pasture in relation to the flavour, quality, and possibly the vitamine content of butter. The determination of the vitamine content of butter requires highly specialized technique and equipment, and might be undertaken at some central institution in Britain (e.g., the Lister Institute; the Dairy Institute, Reading); or under the Animal Nutrition Division of the Council for Scientific and Industrial Research, conducted by Professor Brailsford Robertson, in Adelaide.

(v) The investigation of the interaction of salt and acidity in stored butter.

(vi) Products such as condensed and powdered milk are monopolized by several large companies. These companies usually employ a trained scientific staff, and can doubtless solve their own problems.

(vii) The chemistry of casein and its possible industrial application, and methods of utilizing whey, are phases of research which might occupy the attention of a dairy chemist.

(3) Economic Problems Associated with Dairying.—The systematic investigation of the economics of dairy production is of great importance. Such investigations, so far as they relate to economic production on the farm, should be conducted as a part of the work of a Division of Agricultural Economics which would include the application of economic science to all rural industries.

5. Organization for Research in Dairying.

Some of the more important dairying problems which might be the subject of scientific investigation have been set out in the preceding section. Problems related to breeding and to diseases of stock have not been included in this survey, although obviously they are of great importance to the welfare of the dairying industry.

The investigations described above cover four fields of scientific work:—(i) Dairy bacteriology; (ii) dairy chemistry; (iii) animal nutrition; and (iv) economics.

While all these phases of work are important, it will perhaps be conceded that the most urgent investigations appear to be those relating to the bacteriology and biochemistry of milk and manufactured products. The modern improvements effected in the handling of milk and the manufacture of dairy products are largely due to the advanced knowledge of the biological and chemical changes which occur in perishable commodities. As already indicated, investigations on the application of economic science to dairy production might well be included as part of a scheme for the general economic investigation of rural industries, whilst any investigations on nutrition, so far as they may be carried out by the Council for Scientific and Industrial Research, should be co-ordinated with its Animal Nutrition Division.

There will doubtless be wide differences of opinion as to the precise problems which should be investigated, and the relative urgency of the various investigations listed above. Probably there will be even greater differences of opinion as to what investigations, if any, should be undertaken by the Commonwealth, and which should be conducted by existing State agencies. On these matters, the advice of the Standing Committee of Agriculture will be most helpful.

The possible entrance of the Commonwealth into the sphere of dairy research should not be regarded as in any way relieving the States of their obligation to undertake research in this field. The States should

take their full share of responsibility for problems which they can attack best, and should continue their fine work of applying existing scientific knowledge to raise the standard of dairying practice.

The establishment of a central Commonwealth Dairy Research Institute has been urged in several quarters. Assuming that the Commonwealth embarked on any continuous scheme of dairy research, the establishment of a central institute, possibly with sub-stations or branch laboratories for special investigations, would appear to be inevitable in the course of time. The creation of such a central institute must necessarily involve a large capital expenditure. The capital cost of the National Dairy Institute at Reading exceeds £75,000, and the present annual maintenance costs £13,000 per annum. Proposals have been made for a further capital expenditure of £24,000, and an increased annual maintenance of £6,000 to intensify the existing investigations at Reading. Moreover, it is proposed to establish a second Dairy Research Institute near Kilmarnock, in Scotland.

Apart from considerations of cost, one great difficulty in establishing a Research Institute in Dairying is the scarcity of first-class research workers in dairy science.

Intensive and systematic dairy research is a new enterprise both to the States, the Commonwealth, and to New Zealand. Even in Great Britain, dairy research is a comparatively recent development. Trained specialists for conducting research in dairying are exceedingly difficult to secure. New Zealand is experiencing great difficulty in obtaining suitably trained men to undertake research work in dairy bacteriology and dairy chemistry. Until trained men are available to undertake this important work, and the relative spheres of the Commonwealth and the States in respect to dairy research more clearly defined by experience, it would appear advisable, on all grounds, to begin with a relatively small establishment and staff, and to extend the work as circumstances justify, and as needs arise.

The nucleus of a scientific staff for dairy research would ultimately include a dairy scientist of outstanding ability as leader of the division, and at least three sections—(*a*) dairy bacteriology, (*b*) dairy chemistry, (*c*) dairy nutrition—each under the control of senior research men of acknowledged status in their field of work. Each section would need scientific assistants, and the usual laboratory workers, equipment, and facilities.

The first appointments would include a highly qualified dairy bacteriologist and a dairy chemist. It might be necessary to secure such men from abroad.

Until adequate training facilities were available in Australia, it would be highly desirable to encourage Australian graduates to proceed overseas for post-graduate training in dairy research. On returning from training abroad, these graduates would act as research assistants.

The work of the research laboratories could be extended from time to time by the addition of new sections as needs arose, and as trained men became available; and ultimately there would evolve, from a relatively small initial establishment, a Dairy Research Institute, capable of dealing with the major problems affecting the future progress of the dairying industry, and of co-operating with State institutions in extending and developing dairy research.

Pulping of Annual Grasses, &c., by the Chlorine Process.

*By J. L. Somerville and L. R. Benjamin.**

1. Introduction.

Since about 1915 world-wide interest has been aroused in various processes for pulp making by the use of chlorine as a main reactant. The basic principle of these processes has long been embodied in Cross and Bevan's method for the laboratory purification and estimation of cellulose in lignified plant materials. It consists in the chlorination of the material at air temperature, followed by the dissolution of the chlorlignin compound formed in alkaline or sodium sulphite solutions. This treatment results in the mechanical separation and chemical purification of the fibres of the raw material.

Two processes that have been carried to the commercial stage are those of De Vains, in France, and Cataldi, in Italy. There have been activities in Germany, but the extent of their development is not definitely stated in the available literature. The De Vains process seems to have arisen as an alternative to the soda process for pulp making from straw and esparto, but in Italy the Cataldi process was developed as part of an organized plan, which included the manufacture of electrolytic caustic soda and the disposal of the secondarily important chlorine in any way that could be made profitable. The first Cataldi plant was built in 1916. Both the De Vains and the Cataldi process use caustic and chlorine, but whereas Cataldi, by reason of the origin of his process, uses as little caustic soda as possible, and does the greater part of the purification of the raw fibrous material with chlorine, De Vains uses caustic soda and chlorine in the proportions in which they are obtained from the electrolytic cell.

Polemics have raged round the merits and demerits of the two processes. There seems to be satisfactory evidence that both produce a marketable pulp; the De Vains pulp is perhaps slightly better. The Cataldi process, because of its low caustic consumption, is, however, the only one suited to the economic conditions in Italy. Many conflicting statements have been made about the De Vains product, and it has been compared with both the Cataldi pulp and that produced by the ordinary soda process. It seems certain that the colour of the bleached pulp produced from straw and esparto is better than that produced by the soda process, and the chemical quality is as good, but in the absence of samples it is difficult to decide whether the De Vains straw pulp is, as claimed, softer and less hydrated than the straw pulp produced in Germany by the soda and sulphite processes. Another advantage claimed for the De Vains process is that the recovery of soda is eliminated. There are, however, doubts about the economy of this practice.

It has been found, in previous experiments carried out by the writers, that sorghum stalks gave a good long-fibred pulp by the soda process,† and it was then decided to apply the De Vains process to the material in an effort to produce a high-grade bleached pulp.

---

* Officers of the Council who have been undertaking investigations on the production of paper pulp from Australian raw materials.

† Council for Scientific and Industrial Research, Australia, Bulletin 33 (1927), p. 103.

2. Description of Process.

In order to facilitate discussion of the experimental work, a short account will be given of the De Vains process, and, for purposes of comparison, of the Cataldi process.

The De Vains Process.—The De Vains process is chiefly applied to cereal straws and esparto; it is not, in fact, adapted to the treatment of less easily digestible materials, such as wood. Salt and coal and cheap electric power are the other requirements. The raw material is first cooked mildly with caustic soda obtained by electrolysis in the usual way; when straw is used, the charge of NaOH is from 8 to 12 per cent. of the charge of raw material. The literature gives no very definite information about the cooking conditions used, but apparently four hours' cooking at pressures rising to a maximum of 40 or 50 lb. results in the conversion of most of the alkali charge. The product after washing—known as half pulp—is in a very raw state, the fibres are not at all separated, and it is necessary before chemical attack by chlorine to open up the material by mechanical means. No description has been found of the apparatus used for this purpose, but it is certainly a variety of wet grinding mill. The necessity for this stage is a drawback to the De Vains process, and will partly offset the advantage derived from the elimination of the soda recovery plant. After passing the grinding apparatus, the oversize material is sorted out mechanically, the sand removed by traps, and the consistency of the semi-pulp regulated to the requirements of the chlorinating plant.

According to the De Vains patents, there are two different methods of utilizing the chlorine obtained from the electrolytic cells. In one, the chlorine is obtained from the cells in solution, the strength of which is variously given as 4 to 6 grams per litre. The quantity requisite to supply enough chlorine for the thorough chlorination of the material is added to the semi-pulp, and the mixture stirred in tanks. The figures given for the consistency of the semi-pulp, the strength of the chlorine solution, and the amount of each mixed for chlorination, are in some cases conflicting and generally unsatisfactory, so that it is difficult to arrive at a reasonably accurate figure for the chlorine consumption; but, on the *a priori* grounds that it is consumed nearly proportionately to the caustic soda as they are produced from the cells, the consumption will be about 80 per cent. of the caustic soda consumption, i.e., 7 to 10 per cent. This method is used in practically all the De Vains plants, while the second method of chlorinating the semi-pulp is, as far as can be discovered, not yet in practice. In this second method the chlorine is obtained from the cells as the moist gas, and is then passed into pressure chambers, where the semi-pulp is being stirred, or up towers against a stream of semi-pulp running down over baffle rings. When towers are used, the dimensions of the tower and the rate of passage of semi-pulp would necessarily be dependent on the rate of absorption of chlorine by solution and reaction. Even with the use of very dilute pulp it is to be expected that the flow would be impeded by clogging. In this and other respects chlorination in a pressure chamber would possibly work better. The process is, as with the tower, continuous; the semi-pulp is entered at the top, below the gas space, and stirred during its passage downward to an outlet at the bottom, while chlorine is bubbled in, maintaining a constant low pressure. In order to increase the rate of solution, the chlorine gas should be forced in under considerable pressure through fine orifices to form a shower of small

bubbles. The materials used for constructing these tanks and towers are apparently mainly stoneware and enamelled iron, with Delta bronze, hard lead, or ebonite for smaller parts, such as stirrers and connexions.

According to Cross and Bevan, the chief reaction on chlorination is the formation of chlorlignin compound and hydrochloric acid—

$$\text{lignin} + Cl_2 \rightarrow \text{chlorlignin} + HCl,$$

where 50 per cent. of the chlorine appears as hydrochloric acid; but, according to Waentig, in practice it may be up to 75 per cent. The chlorlignin compound is soluble in alkalies, so by a suitable alkaline treatment and washing the chlorinated semi-pulp is converted into a fairly pure neutral pulp ready for bleaching. According to De Vains the black liquor from the soda cook at the beginning of the process is suitably alkaline, and in his plants the whole of the chlorination product is mixed with the warm black liquor, and the pulp drained off and washed. It is claimed that the alkalies, sodium hydroxide and carbonate dissolve the chlorlignin from the pulp, and that the hydrochloric acid in the liquor and pulp from the chlorinator decomposes part of the organic sodium salts in the black liquor, with precipitation of the organic matter from the mixture in a dilute solution of sodium chloride with the precipitated matter in suspension. It might be expected that some of this precipitate would be retained by the pulp, discolouring it and increasing the bleach requirement, but it is denied that this effect is marked. It seems extraordinary, however, that the pulp from the chlorinators is not, at least, drained to remove most of the hydrochloric acid and to give a stronger alkaline treatment to the fibre. Schacht, when working with a De Vains plant in Germany, did modify the process in this direction, and, in addition, used fresh caustic soda solution to dissolve the chlorlignin.

The washed pulp obtained requires about 2 per cent. of bleach to give a bleached pulp of an excellent white colour. The bleach required is made on the plant from milk of lime and part of the chlorine from the electrolytic cells. The quantity of chlorine used in this way is only about a tenth, or less, of that used in chlorination.

With regard to this non-recovery of soda from the black liquors obtained in cooking, apparently it is found that the high cost of erecting and working a recovery plant, taken in conjunction with the cheapness of electric power in the localities in which the plants are situated, makes it more economical to combine the waste liquors and discard the innocuous product than to produce soda in excess of the requirements of the plant.

The Cataldi Process.—In the Cataldi process a great variety of raw materials is used, including poplar wood, straw, and esparto. They are chipped, or cut up, and subjected to an open boil in weak caustic solution, sufficient to little more than penetrate the material with the liquor. The material is then mechanically disintegrated, as in the De Vains process, but because of the much lower degree of cooking in the Cataldi process, the power consumption is higher. Some of the retained alkaline cooking liquor is removed by pressing, and the mass is then broken up with water and charged in the moist state into vertical brick or tile-lined digesters. The ensuing chlorination is done in three or more stages, the number being dependent on the nature of the material. First, part of the air is pumped out and chlorine is admitted at a sufficient rate to keep up atmospheric pressure within the digester. The

rate of absorption before long slows down because of the limited capacity of the chlorine to penetrate the material, and a weak alkaline liquor is then forced in, displacing the residual chlorine gas. The alkali dissolves out the chlorlignin and neutralizes the hydrochloric acid present, thus preparing the material for a further chlorination, which is carried out when the alkaline liquor is drained off. All these operations are carried out in the same digester, thus avoiding inconvenient handling of the fibrous material. The chief difficulty in this method of chlorination arises from the fact that, owing to the lumpy nature of the mass, the action is liable to be uneven. There is a certain amount of heat developed—the heat of solution of the hydrochloric acid formed—so that local overheating is possible, which is dangerous because of the resulting intensification of the action of the hydrochloric acid present on the fibres. This difficulty seems, however, to have been overcome in the Pomilio plants in Italy. Furthermore, Waentig, working in Germany on a similar process, is of the opinion that, for some obscure reason, hydrochloric acid under these conditions of chlorination is generally not so destructive of the cellulose as it is, for instance, when present in bleached pulp. Judging from the literature, there is very little doubt that the damage to the fibre, in the Cataldi and the De Vains processes, from the presence of hydrochloric acid during chlorination, is negligible.

The alkaline liquors from this process, before and between the successive chlorinations, are used again and strengthened by the addition of caustic soda as required, and are not discarded until their organic content becomes too high. The product delivered from the chlorinators, after screening to remove incompletely disintegrated material, is capable of being bleached to a good white colour with a small consumption of bleaching powder.

The final product by the Cataldi process is seen under the microscope to be mechanically damaged; some of the fibres are torn during the grinding operations, but the resulting difference in the paper-making qualities of the pulp is probably not serious.

Both the De Vains and the Cataldi pulps are, as far as can be judged by the few analyses given, of good chemical quality compared with soda pulps from the same materials. Pomilio admits that the Cataldi pulps have a higher hemi-cellulose content, but he is probably correct in claiming that this is not a serious disadvantage.

The figures given in the literature for the consumption of chemicals in the Pomilio plants operating the Cataldi process are very incomplete and conflicting. For poplar, the caustic soda consumption is about 2.5 to 5 per cent. of oven dry wood, and the chlorine consumption is five to six times this amount. Thus the process is apparently capable of providing an important outlet for surplus electrolytic chlorine.

3. Sorghum Experiments.

The sorghum used in the laboratory experiments with the De Vains process was grown in Victoria. It was stover, that is, the analogue of straw, and is believed to have been lying in the field for some time. The stalk was yellowish in colour, free from mould or dirt, and sheathed to a middling extent with leaf bases. The material was prepared for cooking by stripping off the leaf bases and cutting the cane into 3 or 4 in. lengths. It was found that the nodes pulped less easily

than the internodes, but they were not excluded, because it was considered that preliminary crushing of the cane in the laboratory or in commercial practice would so reduce the nodes that this difference in ease of pulping would be diminished, and that the waste of fibre if the nodes were rejected, or the attendant complications of the process if they were treated separately, could thus be avoided.

The general method of treatment of the chopped stalks for a De Vains pulp was as follows. The cane was cooked by the ordinary soda process, and, after washing, the stringy product was ground between the toothed plates of a laboratory model grinder. The semi-pulp, now sufficiently open to be chlorinated thoroughly, was mixed with chlorine water prepared separately, and the mixture was then stirred at room temperature and at a known consistency, in an open stoneware vessel fitted with an ebonite stirrer, for a time sufficient to allow of the complete absorption of the chlorine. The pulp was then washed and heated to boiling point with a dilute solution of sodium hydroxide or carbonate (not with black liquor, for this was considered to introduce an undesirable complexity), and after a further washing was bleached in the ordinary way. Quantitative data were obtained at each stage, namely, of the conditions of cooking, the yields after cooking, chlorinating and bleaching, the charge of chlorine and time of reaction during chlorination, the consistency during chlorination and the alkaline boil and bleaching, the amount of alkali used in the alkaline boil, and the bleach consumption.

Owing to the circumstance that the chlorination vessel was open to the air, a certain amount of chlorine was lost by escape from solution, and, since no allowance for this could readily be made, the calculated consumptions of chlorine during chlorination are a little too high. The error involved did not seem to be sufficiently important to warrant the construction of a special gas-tight vessel.

In the experiments made, attention was directed only to a number of the fundamental conditions affecting the production of De Vains pulp. The process requires about equivalent consumptions of caustic soda and chlorine, so the first experiments were designed to fix the conditions necessary for this result. Generally, by increasing the consumption of soda in the cook, a purer semi-pulp is obtained, which requires less chlorine in the subsequent stages. In the first test carried out, the cane was cooked at 50-lb. steam pressure for four hours with 7.1 per cent. of caustic soda on the oven-dry cane charge, with a liquor ratio of 11 to 1. After grinding, the material was chlorinated at a consistency of 2.6 per cent. for two hours, in which time 0.206 gram equivalent of chlorine per 100 grams oven-dry weight of original cane was consumed. The chlorination was not carried any further, because the rate of absorption was then very low, and the colour was a very bright orange yellow, indicating that a high degree of chlorination had been attained. The subsequent bleach requirement of the pulp confirmed this conclusion, being only 1.6 per cent. Up to this stage the methods followed were those in use in De Vains plants, but in the next stage the alkaline treatment to dissolve the chlorlignin present and render the pulp alkaline before bleaching, a departure was made, viz., the semi-pulp was washed and heated with sodium hydroxide in small excess. About 0.03 gram equivalent per 100 grams oven-dry weight

of cane was found to be the consumption of caustic soda, which, added to that occurring during cooking, gives the total consumption. This procedure had the advantage of avoiding the controversial question of whether colouring matter from the black liquor is absorbed, and of avoiding the effect of possible variations in the black liquors caused by standing, whilst the heating ensured complete solution of the chlorlignin compounds:—

TABLE 1.

Test No.	Total consumption of NaOH in gm. equivalents %.	Total consumption of chloride, gm. equivalents %.	Sum of NaOH and chloride equivalent consumptions.
A1	0·186	0·220	0·416
A6	0·224	0·181	0·405
A8	0·225	0·199	0·424
A5	0·252	0·133	0·485
A2	0·257	0·179	0·436
A4	0·259	0·106	0·365

The bleach consumption for A1, expressed in terms of gram-equivalent of chlorine per cent. oven-dry cane was 0.014, giving a total chlorine consumption of 0.220, as shown in Table 1. In the other cooks tabulated the conditions were as described for A1, except for variations in the charges of caustic soda used in cooking. It may be seen that, as the consumption of caustic soda increased, which is a direct reflection of an increase in the caustic-soda charge, there was a decrease in the amount of chlorine necessary for complete chlorination and final bleaching, while the total consumption expressed as equivalents was practically stationary. The pulp yields and quality were also approximately constant. This result is in good agreement with a statement made by Strachan, that "in the limits of the De Vains process the consumption of caustic soda and total chlorine are interchangeable in molar quantities," and that "above and below these limits the total consumption of caustic soda and chlorine is greater," and "these limits of most economical consumption of chemicals include the point of equivalent quantities of caustic-soda and chlorine." The figures in Table 1 do not indicate that these limits have there been reached, but the latitude allowable in the operation of the process is partly demonstrated.

Following the practical consideration that equivalent consumptions of caustic soda and chlorine are necessary if recovery of soda is to be avoided, the conditions of A8 were adopted in the next experiment.

Certain criticisms directed against the De Vains pulp were that damaging oxidation of the fibre takes place during chlorination, especially with a high concentration of chlorine and a high-density pulp. The next step was, therefore, directed to an examination of the quality and yields of pulps chlorinated with the same amount of chlorine but at different densities. In the tests set out in Table 2, three densities, viz., 4.1, 2.4, and 1.4 were used during chlorination. The conditions of test A7.3 were aberrant, but the results corroborate A7.4.

TABLE 2.

Test No.	NaOH Equivalents % O.D. cane.	Total chlorine consumption. Equivalents % O.D. cane.	Gms. semi-pulp chlorinated.	Gms. chlorine used.	Density of pulp in chlorinator.	Ccs. total water.	Time. Hours.	Cu. No.	Cellulose.	Yield bleached pulp. % O.D. cane.
A7.3	0·192	..	85	12·1	3·2	2660	2	·87	71·1	50·6
A7.4	0·192	0·208	84	10	4·1	2036	2·5	·67	73·3	51·4
A7.1	0·192	0·198	85	10	2·4	3500	2·5	·87	70·6	51·8
A7.5	0·192	0·204	85	10	2·4	3500	3	·65	71·7	52·2
A7.2	0·192	0·196	85	10	1·4	6000	4·25	·88	71·8	56·4

In A7.4 the concentration of chlorine at the beginning of chlorination was about 5 grams per litre, which is quite high and nearly the limit obtainable, since saturated chlorine water at room temperature is about 7 grams per litre. On the other hand, in A7.2 the concentration of chlorine was only 1.7 grams per litre, and it is shown by the figures that alteration of the conditions in this direction results in a higher yield and a longer time for the re-action to finish, while the chemical resistance of the cellulose expressed as α-cellulose content and the state of oxidation shown by the copper number are nearly constant as compared with cereal straw soda pulp. These figures indicate pulp of good chemical quality. Thus, within and probably beyond the limits of this test, chlorination under more concentrated conditions has the important advantages of greatly decreasing the time required and the volume of pulp handled per unit of output. The concomitant fall in yield is the only disadvantage, but in practice would perhaps be a lesser consideration, especially when viewed in the light of experiments on screening the pulp, a subject that will be discussed later. The chlorination process is slightly endothermic, due to the heat of solution of the hydrogen chloride formed, but it was found in the above tests that no appreciable rise in temperature occurred.

In all these tests the method adopted for the alkaline treatment of the chlorinated pulp was that of washing and heating with about 0.06 gram equivalents per cent. of NaOH or Na_2CO_3. The consumption of alkali was in all cases nearly 0.03 gram equivalent of NaOH per 100 grams oven-dry cane. The reasons for adopting this procedure have already been given.

Having fixed the best conditions of cooking and chlorination, an examination was made by comparative trials of various alternative alkaline treatments. In the first case, chlorinated pulp was washed and then added to the correct proportion of black liquor as drained from the soda cook which constituted the first stage of the process. It was found that the black liquor, which contained only 0.2 grams per litre caustic soda, was not sufficiently alkaline to neutralize the hydrochloric acid and dissolve the chlorlignin compounds in the cold or on heating. The chlorine consumption in the subsequent bleaching increased from 0.0182 gram equivalents per cent., where fresh alkali solutions were used, to 0.0822 gram equivalents per cent. with black liquor, showing that some organic colouring matter was not removed by

the black liquor, and was left to be oxidized away by the bleach. The conditions used in the soda cook—40-lb. steam pressure and four hours—are rigorous for the nature of the raw material, and were chosen to facilitate the control of the alkali consumption by varying the charge of caustic soda. One result is that the black liquor obtained was lower in caustic-soda content than it would be in practice, where a shorter time of cooking and a higher charge of caustic soda would give the required degree of digestion and yield a more alkaline black liquor. The consumption of caustic soda in this alkaline wash is, for all these tests, about 0.03 gram equivalent per cent. oven-dry cane. By consideration of the relative amounts of chlorinated pulp and black liquor, it is found that this amount of caustic soda would be applied to the chlorinated pulp if the black liquor contained 1.8 grams per litre of caustic soda. This could readily be arranged by adjusting the cooking conditions. Black liquor containing this amount of caustic soda would contain also some quantities of carbonate and weak organic soda salts capable of exerting a certain alkaline effect; but it was expected to be too small to be worth investigating in the above tests. A further test was accordingly made, using black liquor to which caustic soda had been added, making a total of 2.0 grams per litre, and on bleaching the pulp consumed 0.0268 gram equivalents of chlorine. To summarize: By the use of a black liquor of a sufficiently high causticity, instead of a fresh liquor, for the alkaline wash, the chlorine consumption during bleaching is increased by 50 per cent. over that after the use of a fresh liquor, and the total chlorine consumption is similarly raised by 4 per cent. In these figures can be seen the explanation of much argument. Some critics of the De Vains process, notably Schacht, have pointed out the rise in bleach requirements due to the use of black liquor, and others, especially Strachan, have, in reply, emphasized the nearly negligible rise in the total chlorine consumptions. Nevertheless, the defendants are in a weaker position than at first appears, because De Vains adopts the undefended and apparently indefensible method of neutralizing with black liquor the chlorination mixture entire, without removal of the acid liquor. The presence of this readily-removable hydrochloric acid would undoubtedly aggravate the differences of bleach consumption shown by the above figures. It would seem that, in practice, much the best plan is to drain and lightly wash the chlorinated pulp before the alkaline treatment is begun.

Pulp produced from sorghum by the methods found most satisfactory in the above discussion is, in the main, of high quality, and a good yield is obtained (51 per cent.). The colour is an extremely good white, and the state of oxidation, as shown by a copper number of less than 1.0, is very low. The α-cellulose content of about 71 per cent. is, however, somewhat low, and the fairly high content, as well as the chemical nature, of the lower-quality cellulose present is probably closely connected with a marked physical feature of the fibre, namely, its "wetness." This feature is shown generally by pulps from cereal straws as compared with those from wood or the textile fibres, and is to be ascribed to two chief factors; first, the relatively high content of low-grade cellulose, which, in addition, may be hypothetically considered to be of a more hydrated nature than the low-grade cellulose of wood pulps; and, second, the presence of fine non-fibrous cellulose particles, being the cell walls of various non-fibrous tissues of the plant stalk. It is the combination of these two factors—degree of hydration and "fineness"—that constitutes the "wetness" of a pulp, and in

the sorghum pulp produced by the De Vains process both are present to a marked degree. Paper made from this pulp, even when unbeaten, has, in consequence, the properties of hardness, rattle, translucency, and lack of absorbency in excess; but, on the other hand, the fine material present in the pulp gives a good close texture. The strength of paper from the unbeaten pulp is remarkably high (the bursting strength found was 82 points per lb. per cent., which is due, apart from the high intrinsic strength of the fibre, to the great length—up to 3.0 mm.—of a majority of the fibres, together with the cementation and felting resulting from the presence of fine fibrous and non-fibrous material, and the high state of hydration of the cellulose as a whole. No direct attempt was made to prove that the fine non-fibrous cellulose of the pulp had a higher content of low-grade cellulose and a greater degree of hydration than the remainder, because of the great difficulty of obtaining satisfactory expression of the degree of hydration, but it was believed that this was the case, and experiments were designed to discover any advantages that might be derived by the exclusion of this non-fibrous cellulose from the pulp.

The removal of this material is most readily effected after the soda cook at the beginning of the process. This cook is so mild that the fibre of the cane is almost all in shives, while the parenchyma of the pith, being unlignified, is completely broken down, making it easy by suitable screening to separate the pith cells from the fibre without material loss of the finest fibre from the smallest fibre bundles. For purposes of close comparison, however, it was found better to remove the non-fibrous material in the finished pulp, which was accomplished by judicious screening through a 60-in. sieve. This treatment reduced the yield of pulp from 51 per cent. to 42 per cent., whereas by screening the semi-pulp the yield was found to be only 35 per cent., but it is likely that this is partly due to the use of too open a screen. This screened pulp was very much freer than before. When made into paper without beating, an improvement was at once noticed, the paper being softer and more pliable, but of slightly lower bursting strength. The translucency was not noticeably altered. Various tests were made to compare the normal and the screened pulp after beating, and it appears that, up to the relatively advanced stages of wetness suitable for bonds, the screened pulp gives a paper greater in bursting and tearing strength by about 6 to 10 per cent. than does the unscreened pulp, but the translucency and feel of the papers are much the same when the wetness is similar. When beaten further, to the "greasy" stage, the paper strengths and appearances are the same, and the removal of parenchymatous material has only the disadvantage of lowering the yield. The bleached bond sheets made in these experiments have bursting strengths of about 110 points per lb. and a tearing strength of 47 grams per sixteen sheets of 50-lb. weight per ream (25 $\times$ 40 — 500), which are adequate, though not remarkably high. The colour is excellent, and the sheets are close and well formed, but they are rather too hard and not sufficiently pliable. The addition of a softer pulp, such as eucalyptus sulphate or soda pulp, considerably improves the paper produced from sorghum. A blend of equal parts of sorghum and bleached soda stringybark (*E. obliqua*) pulps gave an

excellent bond paper with a bursting strength of 103 points per lb. and a tearing strength of 41 grams per sixteen sheets of 50 lb. per ream (25 × 40 — 500).

It may be said, in regard to screening away the slime from the sorghum pulp, that the disadvantage of a lowering of yield from 52 per cent. to 42 per cent. is not compensated by a gain in strength of less than 10 per cent. and a very small improvement in appearance and feel, and that the gain is even less when the pulp is used for blending with eucalyptus pulps.

The "wetness" of a mixture of sorghum and stringybark pulps is, on account of the high "wetness" of sorghum pulp, greatly increased by the addition of the latter, and, although the matter has not been tested, it is possible that the addition of a small quantity of sorghum pulp would increase the rate of hydration of a stringybark pulp. This might result, in practice, in a considerable saving of power for beating when using stringybark pulp for printing and similar papers.

Some samples of De Vains pulp produced in France have attracted attention because of their lower "wetness" (or "greasiness"), making them more suitable for use on fast-paper machines. The reason for this improvement in quality is that in the course of their manufacture a certain amount of fine non-fibrous cellulose is lost through screens, thickeners, and drainers. The above experiments with sorghum suggest caution in accepting predictions that De Vains straw pulp will be extensively used in newsprint manufacture.

An Inquiry into Tasmanian Soil Conditions.

By Professor J. A. Prescott, Waite Agricultural Research Institute, University of Adelaide.

In addition to carrying out investigations at the Waite Agricultural Research Institute as a member of the Adelaide University staff, Professor Prescott also acts as an adviser to the Council in connexion with soil problems. He has recently returned from a short visit to Tasmania, and has furnished the Council with a report on the information he was able to collect at that time. His report is printed below.—ED.

1. General.

In connexion with a suggestion that the Council for Scientific and Industrial Research should undertake soil investigations in Tasmania, opportunity was afforded during January and February, 1928, for an examination of the major soil types of the island, and for an assessment of the nature of the associated problems.

In preparation for the inquiry, Mr. P. E. Keam, Chairman of the Tasmanian State Committee of the Council, secured the co-operation of the local authorities, and maps were made available relating to land settlement, character of the native vegetation, and geology. Topographical maps are not available.

Itinerary:

January 27th.—Southern Agricultural District: Richmond, Sorell, Bream Creek.

January 30th.—Huon Valley—orchard district.

February 1st.—Derwent Valley. Hop-growing areas.

February 6th.—Longford district.

February 7th.—Longford to Smithton.

February 8th.—Smithton—Mowbray Swamp—Burnie.

February 9th.—Basaltic soils of Burnie—Yolla—Henrietta district.

February 10th.—Burnie—Launceston.

February 11th.—Cressy—Deloraine district.

February 20th.—Lake Plateau.

Historical:

The first recorded study of Tasmanian soils is that carried out by the explorer Strzelecki, who, during his examination of New South Wales and Van Dieman's Land, collected a number of soils, and examined them in the light of the knowledge available at the time.* Strzelecki's list is given below. An interesting feature is that some of the farms are held at the present time by the members of the same family as in 1840.

* P. E. de Strzelecki: *Physical Description of New South Wales and Van Dieman's Land*, pp. 400-428. London, 1845.

TASMANIAN SOILS EXAMINED AND DESCRIBED BY STRZELECKI.

Soil No.	Locality.	Remarks.	Original Owner.	Present Owner.
14	Mona Vale, Ross ..	Reclaimed swamp..	Mr. Kermode	E. Cameron
15	Mona Vale ..	Higher level ..	.. ..	..
16	Mona Vale ..	Heavy, less productive	.. ..	..
17	Mona Vale ..	Unproductive soil ..	.. ..	..
18	Brickendon, Longford	Highly productive soil	William Archer, Esq.	W. F. Archer
19	Brickendon ..	Unproductive ..	.. ..	..
20	Longford, Norfolk Plains, banks of Lake River	Highly productive alluvium	.. ..	..
21	Circular Head, Stanley	Highly productive..	V.D.L. Co. ..	V.D.L. Co.
22	Circular Head ..	Marshy soil-meadow grass-productive	.. ..	..
23	Circular Head ..	Heathy plains to southward	.. ..	..
24	Break o'day ..	Alluvial tract, productive	Mr. Steiglitz..	..
25	Malachite, South Esk (Malahide Fingal)	Highly productive..	Hon. Mrs. Talbot	Mrs. Talbot
26	Malachite	Lighter soil—unproductive	.. ..	..
27	Quamby-Meander ..	Heavy productive soil	Richard Dry, Esq.	Probably many owners
28	Quamby	Non-productive ..	.. ..	..
29	Logan, Bothwell (Evandale?)	Medium productivity, dark greyish loam	Mr. A. M. McDowell	Henry Reed
30	Logan	All crops fail ..	.. ..	..
31	Glen-Leith, r. Plenty, Derwent Valley	Original productivity not restored	D. Jamieson, Esq.	..
32	Glen-Leith ..	.. .. ..	.. ..	..
33	North Esk ..	Furthest station on North Esk	Mr. Whittle ..	..
34	Franklin Village, Launceston	Abandoned on account of sterility	.. ..	..
35	Point Effingham, left bank of Tamar	Abandoned ..	Mr. Lawrence	..
36	River Piper, east of Tamar	Abandoned ..	Mr. Newland	..
37	Cape Portland ..	Unproductive ..	Mr. Brown ..	..
38	St. George's or St. Helen's River	Cultivation abandoned	Hon. Mrs. Talbot	..
39	Lake country ..	Virgin upland ..	.. ..	..
40	Western shore of R. Huon (Franklin)	Good timber, wheat, potatoes; now devoted to apples	Wm. Price, Esq.	..
41	Deloraine	Sterility brought about by continued growth of crops without manure	.. ..	..

Strzelecki stresses the importance of geological and chemical studies of Tasmanian soils if the fullest use is to be made of the resources of the country, and if fertility is to be maintained.

2. Later Studies.

From the time of Strzelecki until comparatively recent times, there have been relatively few attempts to study the fertility problems of Tasmanian soils. One of the characteristic interests of agriculturists and bushmen throughout Australia has been the relationship between soil fertility and native vegetation.

In 1864, W. Archer (*Papers and Proc., Royal Society, Tasmania*, 1864, p. 96), gave a list of plant indicators which characterized bad land, inferior pastures, good pasture, agricultural land, swampy land, and running water. The list is too extensive to quote here, but reference may be made to the original paper.

This interest was revived in 1893, soon after the Council of Agriculture was founded. Inquiry was stimulated by a letter from Mr. S. Stewart Field, of Devonport, on indigenous growth as an index of the value of land for cultivation, and the local Councils of Agriculture took the matter up with much interest. The results of the inquiry are set out in the *Journal of the Council of Agriculture*, Vol. II., 1893.* The opinions prevailing at the time are summarized by "Bushman" in a letter to the *Launceston Examiner* (quoted on page 109 of the above journal). The best soils are characterized as red chocolate or brown soils of great depth, which will grow profitable crops for many years without manure (evidently the basaltic soils of the north-west coast are indicated). They are characterized by stringy bark (*Eucalyptus obliqua*), white gum (*E. viminalis*), dogwood (*Pomaderris apetala*), heavy musk (*Olearia argophylla*), with bottom growth of cathead fern (*Aspidium aculeatum, Polystichum vestitum*). This list is practically identical with that of Archer's, published in 1864.

A second group of soils, including brown soils, sometimes stony, and dark soils with black sand is characterized by gum-topped stringy-bark (*E. delegatensis*), blue gum (*Eucalyptus globulus*), silver wattle (*Acacia dealbata*), pear tree (*Hakea acicularis*), cabbage tree (*Bedfordia salicinia*) and ferntree scrub with strong bottom growth of bracken in the sandier types, and cathead fern on the brown soils. Fruit trees are said to do well on northern slopes.

A third group of good soils, heavy brown and black soils, with clay bottom, makes good grass and clover land. This was characterized by swamp gum (*Eucalyptus regnans*), blackwood (*Acacia melanoxylon*), sassafras (*Atherosperma moschata*), heavy tea tree (*Melaleuca ericifolia*, and other Melaleuca species and Leptospermum), dogwood (*Pomaderris apetala*), and stout fern trees. This group is obviously associated with a heavier rainfall, or an abundant supply of ground water.

Poor soils are characterized by peppermint (*Eucalyptus amygdalina*), honeysuckle (*Banksia marginata*), she-oak (*Casuarina suberosa*), native cherry (*Exocarpus cupressiformis*), stinkwood (*Zieria Smithii*), native laurel (*Anopterus glandulosus*), horizontal scrub (*Anodopetalum biglandulosum*), leather wood (*Eucryphia billardieri*), pines with bottom growth of laurel ferns, native hops, and heath.

Myrtle (*Nothofagus Cunninghami*) was not considered as a good indicator, nor was the black wattle (*Acacia decurrens*).

* Pp. 89, 102, 103, 104, 108, 109.

The only Council which was unable to reach a definite decision—that of St. Mary's—reported:—"To arrive at a correct determination on this important matter, an exhaustive examination of the new lands of the colony by a man of scientific attainments would have to be made."

In the following year, the Councils took up the matter of soil fertility, a controversy being started on the subject by Mr. Hogarth, a member of the Agricultural Board. The deficiency of many Tasmanian soils in lime and in phosphate was recognized, although the members of one Council (Chudleigh) reported a conviction that many of the Tasmanian soils require no fertilizers if farmed properly, an attitude which is still to be met with in Tasmania at the present time, particularly in the basaltic areas cleared within the last thirty years.

The first recorded studies on Tasmanian soils along modern lines were published in 1903* by H. J. Coulburn, and at intervals since that time partial chemical analyses have been published. Altogether, some hundreds of Tasmanian soils have been examined, although not always recorded, and a useful purpose would be served if the data could be examined statistically and made generally available.

3. Tasmanian Soils Types.

Tasmanian soils may be classified from two different aspects. The obvious relationship between the geology of Tasmania and the major soil types, is such that, in the past, the natural tendency has been to adopt a geological basis for such a classification. This is primarily due to the fact that, owing to the importance of igneous rocks, the geological map of the island is very largely petrographic, and the more obvious physical features of the soil are definitely correlated with the original parent rock. This system of classification has been adopted by F. H. Johnstone (Appendix I.) in his description of the collection of soils sent to the Wembley Exhibition in 1924, and must form the basis for any future systematic work on the soils of Tasmania.

The most important soils types on this basis are:—

The grey clay loams derived from the *Permo-carboniferous* mudstones and sandstones. These soils are well typified in the Huon Valley, and have proved to be specially suitable for apple-growing.

The *Diabase* soils giving rise to relatively heavy agricultural soils, particularly in the southern parts of the island.

The *Tertiary lacustrine* deposits south of Launceston, in the Longford-Cressy district. These soils, where sandy and gravelly, have been left in timber as in the Epping Forest. They form, however, one of the most important agricultural areas in the island.

The *Basaltic* soils of the northwest coast. These soils are derived from Tertiary olivine basalt, which has frequently weathered to a great depth of chocolate or red-brown soil without developing an obviously characteristic profile.

International System.

An attempt has been made as a result of the present inquiry to classify the soils of Tasmania along the internationally accepted system,

* *Journal Council Agriculture*, Vol. XI.

which is based on a field study of the soil profiles, and on the climatic and vegetation relationships. The soils of Tasmania will probably be found to fall into the following recognized groups, although much further field work will be necessary before the mapping can be definitely completed.

"Black Earth" Soils.—Probably in the regions with 20 to 25 inches of rainfall. Diabase soils on the slopes of Mount Nelson, near Hobart, probably fall into this group.

Brown Woodland Soils.—Probably restricted to the drier areas.

Podsolized Woodland Soils.—Very characteristic of the mudstones and lacustrine soils. The "podsol" profile is particularly well developed in sandy types of many of these soils.

Fen Soils.—Neutral swamp soils, as in the Mowbray swamp. These fen soils are characterized by a growth of tea tree, blackwood, and heavy swamp gum. They are expensive to clear, but give fertile soils suitable for potatoes or for dairying. Very heavy, but rather coarse root crops can be grown.

Acid Swamp Soils.—Characterized by button grass (*Mesomelaena sphaerocephala*), these soils are universally recognized as of little value. Such a swamp examined at Smithton showed a characteristic acid sulphide profile.

High Moor Soils.—True peat, characteristic of parts of the Lake plateau.

Soils with imperfectly developed profiles. Skeleton soils are characteristic of the higher areas.

The position of the basaltic soils in the series is indefinite; this can only be worked out after further laboratory investigation. It is quite possible that the profile is either immature or masked by the large proportion of iron oxide present, but it is probable that they belong genetically to the brown or weakly podsolized woodland soils.

4. Fertility of Tasmanian Soils.

The maintenance of high crop yields in any soil, however fertile inherently, is dependent on the proper use of fertilizers and on the maintenance of an efficient system of crop rotation. Strzelecki noted many cases where yields of 40 bushels of wheat or more, in virgin soil, had been followed within four or five years by average crops of 25 bushels. The remarkably low average yield of potatoes obtained in Tasmania to-day is recognized, in part, as due to the absence of proper information concerning the manurial treatment of the crop, and, in part, as due to the presence of virus diseases.

A characteristic feature of Tasmanian virgin soils as compared with the soils of the Australian wheat belt, is their relatively high nitrogen and humus content. There is no doubt that, under the conditions of crop rotation prevailing, the nitrogen factor is of some importance. This is accentuated by the practical absence of live stock farming in some districts, as at Cressy, for example.

The lime status of Tasmanian soils is also likely to be of some importance. The reaction of Tasmanian soils probably ranges from pH4 to pH8, and if any considerable areas exist with reaction values

between pH4 and pH6, the use of lime must become an important factor. Apparently, the only major difference between the worthless button grass areas of the Mowbray swamp and the productive timber swamp is one of reaction.

The systematic examination of Tasmanian soils, particularly from the point of view of mechanical analysis, would probably establish important relationships between soil types and suitability for apples, potatoes, or cereals, apart from the more general aspect of soil classification. This work would be definitely linked up with the field experiments of the Department of Agriculture, and would have an important bearing on the development of such work.

Summarizing these ideas, it is considered that a systematic examination of the soils of Tasmania along modern field and laboratory lines would be of service in developing a scientific basis for the classification of these soils with respect to—

(i) Fertility with special reference to reaction (hydrogen ion concentration), nitrogen, and humus content.

(ii) The suitability of the soils for specific crops as indicated by the mechanical analysis.

(iii) The position of the Tasmanian soils in the International System of Classification.

The first two items are essentially such as can and ought to be carried out by local workers, with or without outside assistance. The third item is of wider significance, and can better be carried out by some co-ordinating organization such as the Council for Scientific and Industrial Research, working in consultation with the Imperial Bureau of Soils.

Parasitological Research in Relation to the Prosperity of the Live-stock Industry.

By I. Clunies Ross, B.V.Sc., Parasitologist to the Council for Scientific and Industrial Research.

1. General.

That the word parasitology conveys but little to the average layman to-day is perhaps due to the fact that its development as a distinct and separate branch of biological science in general, and preventive medicine in particular has become recognized widely only during recent years. In its widest sense, parasitology comprises the study of all those living forms, whether plant or animal, and whether of the most simple or complex type, which for the whole or part of their existence live at the expense of other living organisms. In its more restricted sense, however, and that usually implied in connexion with either human or veterinary medicine, parasitology is concerned chiefly with the more highly organized parasitic forms, such as the intestinal worms of man, or with well-known parasites, such as the ticks, fleas, or lice, while the study of the simplest unicellular disease-producing forms is considered to be the province of the bacteriologist or protozoologist, rather than of the parasitologist.

During the past 25 years an immense impetus has been given to the study of parsitology by the ever-growing realization of the part played by parasites in the causation of many of the worst scourges from which both man and animals suffer, not only as the direct cause of disease, but to a much greater degree as the transmitting agents of the actual causal organisms of disease. Only at the close of the last century did such discoveries as the part played by ticks and mosquitoes in the transmission of tick fever and malaria respectively head a constantly increasing list of almost equally important discoveries, in which parasites were found to play a vital part as disease producers. Among these it is sufficient to mention such diseases as plague, the various tick-borne diseases of man and animals, sleeping sickness, yellow fever, and typhus. In addition to the entirely new aspects of the association of parasites with disease, it was found in the light of modern knowledge that many parasites which have been known and recognized as of pathogenic importance since time immemorial, were of incomparably greater importance than had previously been recognized. Thus the common hookworm of man was found to be the cause of that widespread mental and physical indolence characteristic at that time of many of the residents in the southern parts of the United States and of other tropical and semi-tropical countries. The nation-wide campaign instituted to effect the eradication of this parasite was one of the factors that ultimately led to the creation of the International Health Board of the Rockefeller Foundation, the world-wide organization for disease prevention which is now carrying on its beneficient work in almost every country on the globe.

So great has the field of parasitological investigation become that it is essential for the graduate, whether medical or veterinary, who would specialize in this aspect of disease prevention work to devote his whole time and energy to it alone, and even then the magnitude of the subject is such that further specialization in one or other of the parasitic groups is often considered to be advisable.

With this necessarily brief outline of the nature and scope of the parasitologist's work it is convenient now to consider the need for, and the importance of, parasitological investigation in Australia, especially in its relation to the prosperity of the live stock industry.

2. Parasites and Diseases of Australian Live Stock.

Even a superficial survey of the more serious diseases which affect each class of our live stock reveals the fact that amongst these none are of more vital importance than those caused by, or spread through, the agency of parasites. In the beef industry we find that perhaps two of the greatest handicaps from which it suffers are due to the presence of two parasites, namely, the cattle tick (*Boophilus australis* and the beef nodule worm *Onchocerca gibsoni*). The cattle tick was introduced from Asia at the close of the last century, and is now firmly established along the northern and eastern coast of Australia, as far south as the Richmond River. It causes annual losses, which, while difficult to compute accurately, are yet of such magnitude that the question of the control and eradication of this parasite has at last been recognized as one of national concern, and one to be undertaken jointly by the co-operation of Federal and State authorities. Not only does the tick exert its harmful effects through the worry and irritation caused by its blood-sucking habits, but it also serves to transmit from animal to animal a microscopic organism (*Babesia bigemina*), which is the causal organism of tick fever or redwater, in which disease there is an extensive destruction of red blood cells, often resulting in heavy mortality among affected cattle. The cattle tick has already cost the State of Queensland millions of pounds, while to-day the States and Commonwealth are expending annually the sum of £150,000 in the effort merely to eliminate any danger of its further southward invasion, and to effect its eradication from New South Wales and immediately adjacent Queensland territory.

Again, our meat export trade is greatly handicapped by the presence in Australia of the beef nodule worm, which gives rise to the formation of hard fibrous nodules in the muscles of the brisket and hindquarters. The importance of these lies, not in any ill effects they produce in affected cattle, but to the fact that no beef containing these nodules can be imported into England or the Continent. In consequence, all beef for export must be mutilated by the removal of those sites likely to contain nodules, and the seriousness of the position thus created will be appreciated when it is realized that Australia's great rival—the Argentine—is not handicapped at all in this way. Yet another parasite now bids fair to rival the cattle tick and the nodule worm in importance. This parasite, the buffalo fly (*Lyperosia exigua*) is spreading rapidly throughout the cattle-raising areas of Northern Australia, and it appears probable that, unless measures are devised to check its onward march, Queensland will be invaded, thus creating a position of which it is

impossible to overestimate the gravity. The buffalo fly produces its harmful effects by means of its painful bite and the continual worry and irritation of cattle subjected to its attack.

Passing from cattle to sheep, we find that here also the losses caused by parasites are greater than those from any other source of disease, if we except such conditions as malnutrition caused by drought and allied factors. The blowfly pest alone causes losses which in certain years have been estimated at £4,000,000, while of lesser magnitude, but still of sufficient importance, are the losses due to internal parasites such as the liver fluke (*Fasciola hepatica*), the various species of stomach worms, and lung worms. Liver fluke disease, over much of the choicest sheep-raising country of New South Wales, Victoria, and Tasmania, ranks as perhaps the most serious disease of sheep, and causes losses which in average years may be estimated conservatively at £100,000, while in certain years this figure may be considerably exceeded. In addition to these internal parasites, external parasites, such as the various species of lice and the so-called sheep tick (*Melophagus ovinus*), owing to the worry and irritation they occasion, cause losses both from diminished mutton production and from deterioration in wool, over a large part of our sheep-raising areas. In Western Australia it has been found necessary to institute compulsory dipping on account of these parasites, while on the other side of the continent, in New South Wales, the same parasites more frequently necessitate the quarantining of sheep holdings than do any other forms of disease.

It is perhaps unnecessary to deal in detail with the parasites of other classes of live stock, but in these, as in sheep and cattle, the injury and disease caused by parasites, though not so obvious, are yet sufficiently serious to constitute a grave handicap to the prosperity of these branches of the live stock industry. In pigs especially it is not unlikely that many of the ill effects attributed to malnutrition and other undefined causes are caused by infestation with the common round worm of swine (*Ascaris lumbricoides*), and that much of the incidence of lung diseases among young pigs is due here, as in other countries, to the same cause. Even the poultry industry pays heavy toll to parasitic infestation by both round and tapeworms and various external parasites, such as numerous species of lice, the fowl tick (*Argas persicus*), and the stickfast flea (*Echidnophaga gallinacea*), and to guard against these sources of loss the poultry husbandman must ever be on his guard.

Such is the magnitude of the economic losses inflicted by parasites of live stock that one is apt to overlook the fact that certain parasites of our domesticated animals may also endanger human health. Australia is, unfortunately, the home of one of the worst parasitic diseases of man—hydatid disease—which in practically every case in this country is spread through the agency of the domestic dog. Again, the danger of man becoming infected with the common roundworm of swine must be considered, and in the light of recent observations the infection of man by the hookworms of the dog is at least a possibility. Sufficient has been said to illustrate the importance of some of the problems of which the solution by the parasitologist is urgently required, and without which the highest potentialities for development of our primary industries will not be realized.

In order that the reason for the apparently indirect and illogical way in which the parasitologist often attacks a problem may be appreciated, it is advisable that there should be some understanding of the chief end which he wishes to attain, and of the methods whereby he seeks to achieve this. It may be said that the principal aim of the parasitologist in practically every case should not be the treatment and cure of disease caused by parasites, but rather the prevention of such disease by the control and, if possible, the complete eradication of the parasite. The cure of affected animals, however, must often be considered also as a very necessary, even if subsidiary, measure. As a result of this departure from what the layman is so apt to regard as the chief end of disease investigation, the parasitologist no longer necessarily concentrates his attack upon that stage in the life-cycle of the parasite in which it causes harmful effects. On the other hand, he seeks first to ascertain whether in this or some other stage it is most vulnerable to attack. In order to determine this latter point, it is necessary to determine the life-cycle of the parasite in its most complete detail. As a result of this determination of the life-cycle, there is often revealed some totally unexpected aspect of the problem, some essential factor, whereby the solution of the previously insoluble problem is made possible.

This may be illustrated in the specific case of the infestation of man in Asia and Africa with certain blood flukes, which are the cause of the serious and very prevalent disease known as Bilharziasis or schistosomiasis, which many Australian soldiers contracted in Egypt during the war. Prior to 1913, the life-cycle of the causal parasite was unknown, and nothing could be done to control the incidence of the disease beyond attempting to cure affected persons. How to prevent man becoming infested was unknown, as was any method whereby the parasite might be eradicated. In 1913-14, the Japanese workers Myiari and Zuzuki, and later an Englishman, Leiper, found that the eggs of the parasite were laid within the veins of man or animals, but then passed out of the body, hatched in water, and the young fluke which emerged had then to make their way into the body of certain fresh-water snails. Having developed within the snails, they emerged, and, swimming about in the water of the pond or stream, they infested man or animals by boring through thin skin. How did this discovery affect the problem of controlling the disease? Firstly, it was now possible to guard against infestation of man by avoiding bathing in snail-infested waters and, secondly, in places where it was possible to kill all snails the disease could be completely eradicated, since without these snails, in which it could undergo development, the life-cycle of the parasite was effectively broken. It is easy to imagine the derision with which the ignorant would greet the efforts of those workers who, confronted with a disease of man, sought its solution in the collection and dissection of snails. Very similar features to those shown by the blood fluke of man are exhibited in the life-cycle of the liver fluke of sheep, and, as a result of the determination of all the factors governing the occurrence of this parasite in Australia, its control is now placed in our hands.

Even in those cases where the newly-acquired knowledge of the life-cycle of the parasite does not lead to the adoption of some fresh and unexpected method of attack, it may, and in very many cases does, lead to the adoption of some slight but possibly vital modification in existing

methods of control, which make all the difference between success and failure. This was seen in the case of what is the largest, and in many countries, the most important of the stomach worms of sheep (*Haemonchus contortus*). When the life-cycle of this parasite was worked out, first by Ransom and later by Veglia, it was found that the eggs of the parasite pass out of the sheep, hatch on the pastures, and the young worms after some days climb up blades of grass. Sheep then become infected by swallowing the larvae as they graze over infested pastures. In this case, though it appears still that the only effective method of attacking the parasite is within the stomach of infested sheep by the use of drugs, it is now known that, if effective medical treatment is carried out every 30 days for nine months, the parasite may be completely eradicated from a property. The principal on which this method of eradication was found was as follows:—At the first medicinal treatment, all the worms in the sheep are killed, then, as the sheep graze, they constantly swallow young worms, and so become re-infested. Subsequent treatments at 30 days' intervals will kill all these young worms before they are able to mature and produce eggs, this taking at least 30 days. Thus gradually all young worms on the pastures at the time of the first treatment are picked up by the sheep, and are then killed before they have laid any eggs, and the pastures, never being recontaminated with eggs, are ultimately rendered clean. The success of this method, of course, depends on the treating of every sheep and the employment of a drug which must be 100 per cent. effective in destroying worms within the sheep. In this, as in other cases, having found out how best to attack a parasite, the parasitologist must then endeavour to find the ideal agent for effecting his purpose. The careful and controlled testing of agents for internal or external application against the parasites themselves, or the intermediate hosts in which they undergo development, is another and very important phase of parasitological investigation.

In addition to the relationship between the life-cycle and control measures, a knowledge of the former may bring to light some material, but previously unrecognized, aspect of the pathogenic importance of a parasite. Thus, prior to the determination of the life-cycle of the common round worm of swine and man (*Ascaris lumbricoides*), the only pathogenic effects exerted by this worm were thought to be those produced by the adult worm in the small intestine. While working on the life-cycle of the parasite during the last decade, Foster, and then Ransom, found that the young worms before commencing developing in the bowel, migrated into the bowel wall, passed thence into the blood-stream, and were then carried to the liver and lungs, finally passing up the trachea to the pharynx, where they were swallowed again, and so returned once more to the bowel. During their passage through the lungs it was seen that the migrating larvae inflicted considerable injury on the delicate lung tissue, and, thus weakened, the latter frequently became unable to withstand the action of pathogenic bacteria, so that pneumonia frequently followed on these artificial infections. Investigation of this possibility in the field showed that much of the lung disease suffered by young pigs was due to this previously unrecognized cause, and it must be considered now that the harmful effects produced by the young worms are comparable in importance to those produced by the adults.

In view of the obscure and diverse points which must be elucidated before the parasitologist, however skilled, can offer any solution of a

problem, it cannot be expected that research, even the most successful, can yield the desired results within a short, or even a limited, space of time. Patience and perseverance are alike essential.

3. The Biological Method of Control.

It is necessary here to deal briefly with a method of controlling plant or animal pests, whether parasitic or not, which has recently been exploited with considerable success, and which, while it may be considered to conform in general to the principles outlined above, is yet sufficiently distinctive to deserve separate consideration. This method, known as biological control, is based on the assumption that plants or animals only increase in numbers to the degree in which they become of economic importance as pests, through some forces, as, for example, the changes exerted by civilization, having disturbed the balance of nature. Under natural conditions it is known that all living forms are preyed upon by parasites or predators, and that these, in their turn, are preyed upon by other parasites, the whole of these interacting forces tending to maintain within certain limits a state of equilibrium. When, however, civilization steps in and removes a species from its original environment to another where conditions are all in favour of its development, and where it is no longer subjected to the action of those restraining forces which previously operated upon it, unchecked reproduction soon results in an increase in numbers to an unprecendented degree, until at last the species may become a serious economic pest. Thus the prickly pear, which on its native heath shows little annual fluctuation in the area covered from year to year, when transplanted to Australia, where it was no longer attacked by the parasites which previously served to limit its growth, soon commenced to spread so rapidly that each year saw hundreds of thousands of acres disappearing beneath its advancing tide. So too with the blowfly, its removal from its natural habitat and the control of its parasites to this new environment, where civilization provided an abundance of food and innumerable breeding grounds in the dead and living bodies of sheep, resulted in its change of status from a mild and not altogether unattractive nuisance to a national danger.

In seeking to apply the biological method of control, the parasitologist first ascertains the conditions under which the species investigated lives in its original environment, and by what species of parasites it is there preyed upon. Having determined these points, he then conducts carefully controlled tests with each of these parasites to ascertain whether their method of attack on the pest species is such that they are likely to exert a marked influence in controlling it, and, further, whether there is any danger of the selected parasite itself becoming a source of danger under the new conditions. When a parasite is found which conforms satisfactorily to the required conditions, it is bred in as large numbers as possible, and then liberated at selected sites, where conditions will be most favorable for its action.

4. What Parasitological Research has done in Australia and what it has yet to do.

We may consider the various parasitological problems in Australia under three headings:—

(*a*) Those problems of which the solution within certain limits is now possible.

(*b*) Problems of which our knowledge is such that a certain measure of control is possible, but in which additional information is very desirable.

(*c*) Problems of which no solution can be offered at the present time.

(*a*) Within this category must be placed certain of our most important diseases of which the solution offered, however short it falls of the ideal, yet appears to be the most satisfactory that we have a reasonable hope of expecting, and which may be put into practice, given only the necessary degree of energy and determination in those responsible for its application. First among such parasitic problems must be placed that of—

The Cattle Tick (*Boophilus australis*).—The information gained in other countries in regard to this parasite, both relating to its life-cycle and the most effective method of bringing about its destruction, has been applied here, after having been substantially modified as a result of the valuable work carried out by the New South Wales Department of Agriculture, Harvey Johnston, and others, to make control measures more suitable to Australian conditions. It may be argued that under existing conditions the employment of the methods advocated is not practicable over a large part of the tick-infested area in Australia. This may be true, but nevertheless in New South Wales the work of eradication is steadily progressing, and it is possible to forsee the day when not a single cattle tick will remain in New South Wales or the immediately adjacent Queensland territory.

The Liver Fluke of Sheep (*Fasciola hepatica*).—The main facts relating to the life-cycle of this parasite were ascertained many years ago, but certain vital details relating to its life-cycle under Australian conditions have but lately been determined. With the information now available it is possible, not only to cure sheep affected with fluke disease, but, much more important still, it is possible to prevent infection of sheep in the future, and to eradicate the disease completely by the destruction of the snail host in which the fluke must undergo its development, and that by the employment of methods which are at once cheap and easy of application.

Hebronemiasis.—This disease is caused by certain stomach worms of horses, and here, too, the life-cycle of the causal parasite, worked out in Australia by Hill, Bull, Harvey Johnston, and Bancroft, has shown the directions in which preventive measures should be applied in towns and cities to diminish very markedly the incidence of this disease. Here again, unfortunately, the measures advocated are much more effectively applied in the city than in the country, but it does not appear that any more satisfactory solution may be expected.

Hydatid disease of man may be considered also as a disease in regard to which the information recently gained of the factors governing its distribution in Australia have enabled certain modification in the measures necessary for its control to be suggested, and there is no reason, other than the lack of an intelligent and informed public opinion in country districts, why this disease of man should not be completely wiped out.

(*b*) Under the heading of disease of which the control is to a certain extent possible, but in which additions to our knowledge are very necessary if this is to be completely effective, are many of our most important parasitic diseases:—

The Blowfly Pest.—It may be considered that the placing of blowfly in this category is not justified, in view of the difficulty of controlling its ravages experienced to-day. There is no doubt that efficient supervision of smaller properties, especially with the effective destruction of carcasses and the breeding grounds of the fly, together with the employment of fly-traps and seasonal crutching and jetting, may reduce the losses caused by fly attack to a very small fraction of those sustained before the adoption of these measures. Nevertheless, there are grounds for hope that some more effective and easily applied measure for the control of this pest will ultimately be devised, and this may yet be found in the biological method of control.

The Stomach Worms of Sheep.—The problem of controlling and eradicating stomach worms of sheep in Australia is complicated by the fact that in this country a small stomach worm, *Ostertagia circumcincta,* appears to be of very great importance, while measures advocated in other countries have been directed primarily against the large stomach worm *Haemonchus contortus.* The problem of controlling *Ostertagia circumcincta* is made more difficult by reason of the worm's greater resistance to medicinal treatment, and the fact that up till the present time the life-cycle of the parasite was unknown. Work is now in progress to determine how control measures may be adapted to meet this local variation in the problem of stomach worm infestation.

Sheep lice and sheep tick also are parasites in regard to which certain factors governing their distribution and occurrence are still obscure, while surveys are also necessary to determine the pathological importance of the roundworms of swine, and especially of the large roundworm *Ascaris lumbricoides* in this country.

(*c*) First and foremost in the category of problems of which no solution can be offered at the present time must be placed the beef nodule worm. In spite of much valuable work which has been carried out by skilled workers, it has not yet been possible to determine the life-cycle of this parasite (*Onchocerca gibsoni*), and, lacking this, the measures necessary for its control cannot be suggested.

The Buffalo Fly.—Though the life-cycle of this parasite has been determined by Hill, it is such that no satisfactory measures for its control are yet possible. It is hoped that in the case of this parasite biological control may prove of value.

Such, then, is the position in regard to some of our more important parasitic problems to-day. Much has already been accomplished, and much remains to be done, but there is little doubt that valuable progress will be made in the future, given only the necessary facilities for the conduct of research, and, above all, a sufficient number of men of the necessary skill and training to carry it out. The problem of obtaining the requisite number of men who are qualified to undertake parasitological research in veterinary problems is of sufficient importance to justify dealing with it in some detail.

5. The Training of the Veterinary Parasitologist and the Utilization of the Results of Research.

The parasitologist who would investigate veterinary problems requires a considerable knowledge, not only of the zoological side of his work, but to an equal degree of the pathological and physiolcgical aspects of the problem to be investigated, since these are so intimately interwoven that lack of the requisite knowledge of any one of these might constitute a considerable handicap to the successful conduct of the investigation. This being so, one would expect that the most suitable source from which to draw men who are qualified in the highest degree to undertake this specialized work would be the veterinary schools of the Commonwealth.

Another factor which has a vital influence on the benefit which accrues from successful research on diseases of animals is the degree of appreciation of these results by the live stock owner and the co-operation which he is prepared to give in utilizing them. Were all the measures which have been advocated for disease prevention put into practice at the present time, it is undoubted that even without further research there would be a substantial increase in the prosperity of the various branches of the live stock industry. Further, the lack of a close association between the two vital factors in disease prevention—the research worker and the live stock owner—is liable to cause the latter to adopt a wrong attitude of mind in regard to the part he has to play. Too often he has come to regard his role as that of passive acceptance of benefits accruing to him from scientific research, without at all appreciating the need for his active co-operation. The solution which he expects is one which is applicable without effort or expense, and which will be immediately and completely successful. Where these desirable features are absent in the solution offered, half-hearted co-operation may soon dwindle to apathetic acquiescence, to be followed not infrequently by definite opposition. Any scheme, therefore, of parasitological research should not only include provision for the training of parasitologists, but also for the most rapid and effective method whereby the results of research should be made available to the live stock owner, at the same time ensuring his intelligent and sustained co-operation in the work of disease prevention and eradication.

China Clay Preparation in England and Czecho-Slovakia.

By R. C. Callister, Officer-in-Charge of the Council's Ceramic Investigations.

Towards the end of 1926, Mr. Callister was sent to England on a twelve months' visit. While abroad, he spent a considerable time working under Dr. J. W. Mellor at the well-known Pottery School of Stoke-on-Trent. He also visited Cornwall, and studied the methods there adopted both for exploiting clay deposits and for subsequently treating the material won. During the period, he also spent a short time in Czecho-Slovakia. After obtaining a considerable experience in all branches of the ceramic industry, and partcularly in regard to clays, Mr. Callister has now returned to Australia. The following paper has been written in the light of the experience gained.—Ed.

1. General.

Of recent years, the mining and treatment of certain crude clay deposits in order to extract the china clay content, has grown into a big industry, and, as a result, in many countries numerous industries have come to rely on prepared china clay as one of their essential raw materials. In England and Czecho-Slovakia, the term china clay is applied to the clay which has been extracted by a small range of elutriation processes from primary or secondary deposits derived from altered granites, the alteration consisting of the change from felspar to clay substance, with the quartz unaltered, and the mica chiefly converted to muscovite. Apparently no other material is referred to as china clay, but the prepared china clay is so readily available in commerce that the fact that it has been subjected to an extensive preparatory treatment often appears to be forgotten. The industries using it fall into two main types:—

(i) The non-ceramic group (in which the clay is used merely as a filler); and

(ii) the ceramic group (in which the clay is applied to ceramic purposes, which involve subjecting it to firing conditions during one phase of manufacture).

Curiously enough, the consumption by the ceramic group is not nearly so great as that by the non-ceramic group. The production of clay in Czecho-Slovakia was stated by Dr. R. Barta to be over 400,000 tons per annum, while the output of the mines of Cornwall and Devon approaches 1,000,000 tons per annum.

Both groups demand and obtain a material which meets their requirements in the matter of colour, uniformity of quality and purity, and freedom from gritty, specking, colouring, or fluxing materials, together with ease of blunging and working. In addition, supplies must be regularly available, and at a reasonable cost. These properties are obtained by rather different methods in different localities as a result of adaption to local conditions. The amount of overburden varies, also the method of mining; and questions of water supply, labour, power, space available, turnover, the possible use of by-products, transport, and differing behaviour of the clay concerned all result in the development of methods to suit each particular case.

Practically, all the crude china clay or kaolin consists of a mixture of the china clay with quartz and mica chiefly, but also with felspars, tourmaline, and rutile, as impurities. As already mentioned, these clays are derived from granites which have been altered, and they are mined *in situ* as primary kaolins. Secondary deposits are also exploited, but these in general have been transported a relatively short distance with little enrichment of the clay content.

The three chief clay preparatory processes are:—

(i) electro-osmosis;

(ii) the sand wheel and sedimentation, followed by filter pressing; and

(iii) the elutriation or sedimentation process of Cornwall, where the final product is dried by heat after removing excess water by settlement and decantation.

These processes are in most respects variants of a type method, and their differences will be referred to in some detail.

2. The Electro-Osmosis Method.

At Chodau, near Carlsbad, in Bohemia, is a large clay treatment plant in which the osmosis process is applied to the large scale production of china clay. The plant is located on a long, gradual, rather bare slope, and being built of concrete (in which the quartz product of the process was used), it looks neat and clean. The inevitable branch railway enters the works.

The crude kaolin, containing some 15 per cent. of moisture, is delivered to the works in trucks hauled by an endless rope from a mine about 1 kilometre distant. The deposit is an almost horizontal bed of kaolin 60 feet thick, but overlain by some 30 feet of overburden. The top 6 feet or so of stained clay is rejected. The clay below is obtained by mining methods. This kaolin is of the Zettlitz type, and the deposit is an extensive one underlying many square kilometres of the Chodau district. At the works, it is fed into four blungers of a semi-cylindrical type, fitted with horizontal helical agitators, along with return slip from the osmose machines and some water. The sand is worked down the blungers or washers to where "sand wheels" are operating. On these wheels are small perforated buckets by which the sand is lifted, the slip drained off, and the sand emptied on to a plate to then pass down into trucks. In a similar blunger, the sand from the first blungers is re-washed to give another 4 per cent. of clay and clean quartz sand, which is sold for concrete making. The overflow from the blungers runs through one of two sets of concrete troughs placed three in parallel, and each of which measures 1.68 x 1.46 x 13 metres. In these, a considerable amount of fine sand and mica—20 per cent. of the total crude material handled—settles out to be removed at intervals to the dump. The total sand product constitutes 64 per cent. of the original.

From the sand troughs, the clay stream flows to a series of channels, also in duplicate, and used alternatively, with three parallel channels, with a total width of 1.30 metres, 0.48 metres deep, by 160.0 metres long. The depth of slip is adjusted so that the time for settlement while flowing through these troughs is about 70 minutes. We see then

that the sedimentation process, as practised here, is to allow a considerable time for settlement from a thick, thoroughly dispersed slip (1·24 sp. gr.=31. per cent. slip), and this is in contrast with the Cornish practice. The sediment in these channels is 24 per cent. of the input to the works, and is a second grade clay, grayish in colour, and used mainly as a paper filler.

The overflow from the channels carries a high-grade clay, which is conveyed from agitators to a series of electro-osmose machines. In these, some of the clay is deposited (under the direction of a direct current at about 100 volts and 170 amps., from a slip of 1.22 sp. gr. containing virtually 30 per cent. of suspended clay) on the revolving anodes, which are made of an alloy of lead and antimony. Actually, S. R. Hind found only 9 per cent. of the suspended material is removed during the passage through the machines. This amount is removed from the drum by a scraper in a sheet ⅛-inch thick, and is then trucked to a pug mill.

An inch below the anode drum is a cathode grid to which impurities and water should travel, but the evidence now points to the purification being completed in the channels, and to these machines being only de-waterers. Below the cathodes are agitator arms. The anodes are 4 ft. 8½ in. long x 2 feet in diameter, and revolve once in 3⅓ minutes. The overflow from the osmose machines is sent partly to two electro-osmose filter presses, and partly returned to the blungers. The sodium silicate electrolyte is added in the requisite amounts to this return slip. The filter presses have plates of lead antimony alloy and of copper. These plates are covered with cloth, but all the slip which enters deposits all its suspension in the presses, so that no purification by osmosis is attempted there, while the cakes presently pass through the above mentioned pug mill. The osmose process therefore serves to replace filter pressing, and to dispense with the need of re-flocculating the dispersed clay suspension. The cost of power is approximately ½d. per unit, and Mr. Hind's figures indicate the cost (for power) of separating a ton (2,240 lb.) clay in or by the machines to be 3s. 8d. The osmosed clay is dried in humidity driers, and bagged. We were informed that 80 per cent. of the final product is exported.

The second grade clay is dried in a rotary drier, heated by producer gas made from local brown coal. That the process can compete under these conditions is shown by the rapid growth of the output, and the numerous extensions to the plant. The total output of clay seems to be almost 20,000 tons per year.

3. The Method of Sedimentation and Filter Pressing.

The second type of preparation process is not very different to the one already referred to, but I was very interested to find on some porcelain factories in Czecho-Slovakia clay-washing plants operating on crude Zettlitz kaolin. The washers or blungers in use were similar to those at Chodau, and the quartz sand was removed by vertical sand wheels, and presently dumped. The clay suspension flowed on through concrete channels to be purified by allowing the impurities to settle. It then passed to thickening or settling tanks, from which it was withdrawn for use as a body ingredient, or filter pressed in iron presses, and then incorporated in bodies. The turnover was comparatively small, and the plants also were fairly small. No tonnages or costs were

made available. While these small installations gave the factories control of the clay, and some of its properties, they might easily make blending for a uniform product more difficult, because of the smaller quantities handled.

A large scale treatment plant of this type was operating on a large deposit of secondary kaolin at Horni Briza. Forty years ago, the district was all pine forest, but now there is a very large mine and several large factories all still closely surrounded by pines. This deposit contains 35 per cent. of china clay, and was formed by river action. Some discoloured portions which are not washed occur in it, also some "pockets" of clay (free from quartz), which are plastic, and which are kept separate for use as ball clay. The deposit is nearly horizontal, and is 180 feet thick below 30 feet of stained overburden. It is mined from a series of benches in summer, and from adits and stopes in severe weather. The pit is now some 300 yards by 200 yards at the bottom, and the crude clay is hauled from it to the works, and put through the usual type of blungers, but one grade of the sand produced is of uniform size, and clean, and 120 tons per day are sold to glass works, the coarser quartz being sold to concrete makers. Twenty per cent. of the total material is dumped as impure quartz and mica, in part, into worked-out ground. After the fine sand, mica, and coarser clay are removed by settling, the slip is filter pressed, and the press cakes are removed for drying. This drying is done mainly by hot air tunnel driers, though a large number of roofed, open-sided sheds, with tiers of shelves, provide an alternative method, or additional drying facilities, when required.

The raw clay is nearly free from TiO_2 and the Fe_2O_3 contents range from 0.45 per cent. to 0.8 per cent. The output is 80,000 tons per annum, and 80 per cent. is sold as a paper filler, bringing the equivalent of £2 per ton f.o.b. trucks on works. The remainder is used in part by the company in making wall tiles, while the less pure portions provide the raw material used in their firebrick works near by.

4. Cornish Methods.

The third type of production is that evolved in Cornwall, where very large deposits are being dealt with in open pits, by hydraulic methods of mining. The water is conveyed by pipe lines, and delivered as jets through 1-in., $1\frac{1}{4}$-in., or $1\frac{1}{2}$-in. nozzles, as required. The nozzles are of the usual type, swing from a ball and socket joint, and are manhandled. The head of water is usually natural, though sometimes it is assisted by a pump, and usually exceeds 60 lb. per square inch, with a delivery of from 700 to 900 gallons per minute. When operated from a few feet back from the face, such jets of water cut in freely, producing a milky looking stream, which, after depositing the coarse sand, contains usually a little over 2 per cent. of material in suspension when it reaches the head of the "micas."

The quartz deposits freely at breaks in the flow of the stream, so the channels across the pit bottoms to the sand pits are kept narrow, and they result in the quartz sand being rolled along, even when it drops out of suspension. From the sand pits, the clay suspension flows out through an adit to a pumping chamber located in a shaft sunk to accommodate the pump columns, which raise the slip to the head of

the treatment plant. Many of the pits are 250 feet deep, and at the surface cover many acres. The sides are surprisingly steep considering the wet climate, and the nature of the clay ground. The surfaces are usually grey from the residue of quartz grains left by rain and water action after the clay has been removed. Very often one face is composed of granite which has been washed clear of clay. The water jets operate low down on the faces, and, in fact, they are used in conjunction with centrifugal slurry pumps to deepen the mines, especially in those numerous cases where the pit bottom is below the adit level.

The original granite, before it underwent pneumatolytic alteration, was traversed by veins and lodes and stringers of quartz and elvin. Some of these intrusions require blasting to prepare them for removal. The biggest noticed was some 20 feet wide, and it was still a problem at a depth of 160 feet. Besides these continuous intrusions, numerous pebbles and boulders of various materials, too hard for the jets to break, accumulate at the bottoms of the faces, and have to be trucked away and raised up the inclined tramways to the huge quartz dumps usually roughly conical as a result of the operation of self-tipping trucks. The original granite appears to have contained some biotite and black shorl, and tourmaline is still abundantly present. As there is a good deal of the latter mineral in the quartz dumps examined, it constitutes a very good reason why the glassmaker does not use these heaps.

The bulk of the water used enters the mines as rain, and as seepages from the channels of quartz and other veins which traverse the kaolin. The china clay itself is termed "staunch" to water, but the supply along the breaks made by the veins is such that no water conservation is required, though of course water is returned from the surface plants. In the mines visited, there was always some variation in the appearance and quality of the clay showing in the faces, but by judicious operation a blended and uniform product was obtained, and great care was taken to adjust, and then maintain, a standard of production. Nevertheless, some mines produce a range of products, which vary from very specially elutriated material for cosmetics and special lines, to paper clays, and then to potting clays. The paper clays require good colour properties in the raw condition, while these properties are required in the fired condition in the potting clays. The production of clay varies from 15 to 35 per cent., according to the amount present in the ground being worked, and as it costs approximately 25s. to produce a ton of clay, whether it is best, good, or medium quality, the best clays at the best prices are naturally much the most profitable.

There is no definite knowledge of the reserves of clay available, but the largest appear to be on Dartmoor. The deposits do not appear to have been bottomed, and it is annoying to certain present day operators to have to remove as overburden the residues which their predecessors put back into their old workings. In one mine, these old workings had penetrated, perhaps, 50 feet into the clay, and the present pit was down 240 feet. Mention was made that, in a tin mine, one vein of kaolin was cut at successive levels down to 1,250 feet, but the present open pits cannot be deepened indefinitely even if the clay persists to much greater depths than at present worked. When deepening the pits below the adits to the pumping shafts, the centrifugals, used to lift the quartz and clay, are often erected in sheds on platforms

on wheels running on inclined rails. The whole is attached to the end of a wire rope, so that in the event of a rush of storm water it can be raised out of harm's way.

Some shovels of the Ruston type are in use for handling and removing overburden, which, in the mines seen, would average 15 feet in thickness. Some top clay is also rejected in addition. In other cases the thickness is only 5 feet. The sand pits are gradually being made on patterns which facilitate their being emptied into trucks by bottom discharge, with a minimum expenditure of time and labour. By using electric light freely, operations can be continued at night. One pit, with a surface area of some 15 acres, required with its dumps and surface works a total operating area of nearly 50 acres.

After the coarse quartz sand has been removed, and the clay stream raised to the surface, it is discharged into channels, where fine quartz settles. It flows thence into the "micas." These are shallow channels in which the flow is checked, and in which an extensive separation of mica, quartz, felspar, and tourmaline takes place, and, of course, some clay also settles. When the flow of slip is diverted, the micas are cleaned, and the sediment is run off into a subsidiary plant where some further china clay is recovered. The 2 per cent. suspension of clay is in the micas for a very short period, the time varying from ten to twenty minutes, yet the separation is a satisfactory one. No electrolytes are used to bring about dispersion, and the rate of flow through the channels is considerable, approaching 2½ miles per hour. On one somewhat recently equipped plant, concrete has replaced the older masonry, and the layout is more compact. In all cases, micas are situated in the open.

After leaving the micas, the slip is successively thickened until it enters the "drys," often as a mixture containing one part of clay to one of water. This thickening is a very slow process. The final product is dried to a moisture content of 10 to 14 per cent., and then removed for shipment. It has been found that from a pottery point of view the long contact with water in the settling tanks, followed by the heat treatment in the "drys," produces a much more plastic and workable clay than if a partly thickened slip is filter pressed, and then rapidly dried and marketed. The "drys" are costly to build, and though mainly coal fired, some firing by oil is also practised, and troubles with the burners have not been entirely overcome. The cost of the drying process is in the neighbourhood of 3s. 6d. per ton. It is interesting, after inspecting a series of settlers, thickeners, and drys, to find that the mine and the micas are at the further end of a 6 or 8 mile pipe line, and that though the pipes are mainly of glazed earthenware or stoneware, the use of cast-iron pipes is quite extensive.

Mines with a yearly output of 40,000 tons of china clay are quite common. By previous experience the most favorable outlets for the products of different mines are known, so that the bulk of the output of one pit may go to the United States for paper filling; that of another may be specially suited for the linoleum industry, and as a filler in common papers; that of another may be destined for use in the production of the best papers, and in other industries requiring a good filler; and finally the product of another pit may be largely used for potting purposes.

5. Typical Analyses.

A table is given below of the ultimate and rational compositions of some typical prepared china clays, but unfortunately I have no figures for the crude kaolins.

—	Osmosed Product. (Czech.)	Settled Product. (Czech.)	Zettlitz Kaolin. (Czech.)	Lee Moor Clay. (English.)	M.W. (English.)	J.M. (English.)	K. 16. (Australian.)
SiO_2 ..	45·13	45·66	46·74	47·10	47·36	45·08	45·45
Al_2O_3 ..	37·89	37·12	37·96	39·42	38·05	38·34	38·77
Fe_2O_3 ..	0·94	0·87	0·72	0·23	0·91	0·66	0·25
TiO_2 ..	0·51	0·01	0·43	0·13	..	..	0·43
CaO ..	0·48	0·46	0·43	0·31	0·11	0·94	0·22
MgO ..	0·29	0·01	0·24	0·24	0·14	0·60	0·05
K_2O ..	0·78	0·88	0·65	0·16	..	..	0·34
Na_2O ..	0·58	0·74	0·48	0·08	1·24	1·98	0·09
Loss on ignition ..	13·52	13·86	13·08	12·24	12·19	12·40	14·32
Clay Subs.	90·2	88·5	94·0	99·0	92·5	90·0	94
Felspar ..	8·1	9·7	6·0	1·4	7·5	11·0	4
Quartz ..	..	..	..	..	..	..	..
Fe_2O_3 ..	0.9	0.9	..	..	..	..	..
CaO ..	0.5	0.5	..	..	..	..	..
Cone ..	36	36	..	..	35	36	..

For comparison, an Australian china clay analysis of material from which quartz and mica have been removed, is included in the table.

These figures do not account for the differences in raw colour, nor for the different grain sizes, different behaviour towards the same glaze, &c., but they show how similar are the compositions of clay materials, even when obtained from widely different sources.

As regards the English deposits the whole output comes from three quite small areas in Devon, Mid. Cornwall, and adjacent to Land's End. The output from the latter area is small; that of Mid. Cornwall is at a high level, and the prospective resources of virgin good clay ground appear largest on Dartmoor, in Devon. In common with other mine products, china clay is a wasting asset, and in some quarters some regret has been expressed that such large quantities of excellent material are being sent away, and that no reserves are being made and held, even though no shortage will be evident in this generation.

6. Conclusion.

When ultimately a similar industry is established to give equally careful preparation to some of the local Australian granitic china clays, it is probable that neither of the three processes referred to above will be followed, especially in the earlier stages of handling and treatment, In Australia, another type of kaolin—one formed as the result of the kaolinization of felspathic dykes—has mainly met the local pottery demand up to the present.

When the consumption increases, and the demands become more varied, more attention is bound to be paid to the granitic kaolin as a source of china clay, and then elutriation data and the most suitable process of the above general type will doubtless be considered and installed.

PLATE 1.

Forestry School, Canberra. Commenced 1.7.26. Completed 20.6.27.

[*Block by courtesy of Federal Capital Commission.*]

C.4525.

PLATE 2.

Section of china clay (koalin) workings at Horni-Briza (Czecho-Slovakia) showing working benches and adits.

NOTES.

Conclusion of First Volume of "Journal."

The present number is the fourth issue of the first volume of the *Journal.* In order to arrange that future volumes will correspond with calendar years, it has been decided to make the first volume consist of six numbers. The first number of volume 2 will be issued in February, 1929, and the last number of that volume in November, 1929.

Secretary's Leave of Absence.

The Secretary of the Council—Mr. G. Lightfoot—left Australia in the middle of April last on long service leave. He will be away for about eight months, the greater part of which time he intends to spend in Great Britain and other European countries. Advantage will be taken of the opportunity to visit various research centres, and to gather full information regarding the newer ideas of the organization of research activities.

In Mr. Lightfoot's absence the Assistant Secretary—Mr. G. A. Cook—will be the Acting Secretary of the Council. In addition, Mr. W. E. Cohen, of the pulp and paper section, has been temporarily transferred to the head office.

Division of Economic Entomology.

Progress has been made with the organization of the Division of Economic Entomology of the Council. The Chief of the Division, Dr. R. J. Tillyard, left Australia towards the end of April on a visit to Europe and America, where, *inter alia,* he will make arrangements for the study and supply of insects likely to be beneficial in connexion with the control of Australian insect and plant pests. Mr. G. F. Hill, who has been on the Council's entomological staff for some time, has been appointed as second in command of the Division.

Amongst the noxious weed investigations a commencement will be made with St. John's Wort. A blow-fly "scouting" section for the collection of likely parasites will also be established. In both these cases investigators will, in all probability, be initially stationed in Europe. Noxious insect investigations in general will also be undertaken. In addition, central laboratories and insectaries will be established in Australia, where effective measures for the quarantine of insects may be taken.

Applications have been invited for three positions of "Senior Entomologist," in order that effect may be given to the above programme. Other vacancies will probably be filled by research students who have been appointed under the Science and Industry Endowment Act, and who are now nearing the completion of their respective periods of training abroad.

Fifth Meeting of the Full Council.

The fifth meeting of the full Council (for Scientific and Industrial Research) was held on the 11th, 12th, and 13th of April last. The main purpose of the meeting was to consider estimates of expenditure for the forthcoming financial year. In addition, a welcome was extended to the Chairman of the Council, Mr. G. A. Julius, on his return to Australia from a visit to Europe and America. During the course of that visit, Mr. Julius obtained much information concerning research activities and the organization of research institutions in general, and also made preliminary arrangements for several lines of co-operative work. The more important matters discussed by the Council were as follow:—

Division of Economic Botany.—It was decided that the major groups of related activities of the Council would be known as Divisions, and that the officers in charge of those Divisions would be known as Chiefs. Dr. B. T. Dickson, who had originally joined the Council's staff as Chief Mycologist, was appointed as Chief of the Division of Economic Botany. The organization agreed upon as necessary for that division is as follows:—

> The appointment of (i) a deputy or second in command to Dr. Dickson (ii) two Senior Plant Pathologists and one Senior Plant Physiologist; and (iii) four juniors, two to be plant pathologists, one a plant physiologist, and one a plant geneticist. The problems agreed upon as appropriate for study by the Division include (i) diseases of plants, such as virus diseases in general, tomato wilt, smuts and rusts of cereals, &c.; (ii) mycological problems of industry, including a large group of troubles occurring in the transport and storage of food; (iii) plant genetics, especially in regard to the inheritance of disease and drought resistance; (iv) plant physiology, such as problems of the determination of growth requirements of crop plants; (v) fundamental work relating to plant introduction, agrostology, weeds, poison plants, &c. Of the above programme, it is proposed to give early attention to bitter-pit in apples and to diseases of cereals.

Proposed Tropical Agricultural Research Institute.—The different forms of organization that had been put forward for this proposed Institute were discussed at length. It was decided to wait until Sir Arnold Theiler, Dr. J. B. Orr, and Dr. B. T. Dickson had visited Queensland before making any definite recommendation on the matter.

Report by Dr. A. W. Hill, F.R.S., &c., Director, Royal Botanic Gardens, Kew.—The main recommendations of this report are to the effect that (*a*) a National Herbarium be established, and (*b*) that improved facilities be made available to the State Herbaria.

It was decided to refer the section of the report dealing with State Herbaria to the various State Committees of the Council, and to ask each Committee for advice as to what should be done so far as its particular State was concerned. It was generally felt that the establishment of a National Herbarium, while very desirable, should not be placed in the forefront of the Council's activities.

Dairy Research.—The resolution passed on this matter at the meeting of the Standing Committee on Agriculture held on the 12th

March (see page 252) was endorsed, and it was decided to recommend to the Minister that two appointments of (i) a dairy bacteriologist, and (ii) a dairy chemist, be made.

Animal Diseases.—Progress was reported in the various investigations of animal diseases, such as braxy disease in sheep, parasitological work, contagious pleuro-pneumonia, &c., being undertaken by the Council. Sir Arnold Theiler, who was present during this part of the discussion, said that he had been impressed by the rapid progress that had been made in the Kimberley, or "walkabout," horse disease, and that similar troubles occur in other parts of the world.

Animal Nutrition Investigations.—Professor Brailsford Robertson, who is in charge of these investigations, outlined the progress that had been made. A stock of laboratory animals is being bred up for fundamental work on protein and mineral deficiencies in diets. In addition, simple field stations are being established in various parts of Australia to obtain further information on existing deficiency conditions. A report on the chemical constitutions of various Australian wools, which are intimately connected with questions of diet, will be completed at an early date. An iodine survey of sheep thyroids from various localities is also being undertaken, and an effort being made to correlate the results with wool quality.

Entomological Investigations.—The Council discussed the question of entomological investigations at length. During this discussion, the Chief of the Division of Economic Entomology—Dr. R. J. Tillyard—was present. It was considered that so many entomological problems of a major order of importance exist in Australia that an extensive organization is necessary to study them, prior to there being any hope of control measures being established. The organization decided upon is discussed elsewhere in these Notes.

Forest Products.—Consideration was given to the report on forest products furnished to the Council by Mr. A. J. Gibson, I.F.S., and mentioned elsewhere (see page 254). The report does not include any suggestions for the using of existing institutions, but, instead, proposes a central Forest Products Laboratory. It also proposes that forest products research should come directly under the control of the proposed Federal Bureau of Forestry. It was generally felt that the initiation by the Council of forest products research work on the scale pictured by Mr. Gibson, although ultimately very desirable, could hardly be justified at the present time. It was realized that the work proposed on the determination of the strengths of timber would involve a considerable expenditure, and, mainly for that reason, it was felt that the Council could not undertake it at present. On the other hand, it was considered that investigations on the preservation and the seasoning of timber, and on the utilization of forest waste, all of which are comparatively inexpensive, could well be undertaken. Further consideration of the whole matter was left to the Executive Committee.

Liquid Fuel Investigations.—Mr. Julius stated that all his recent inquiries had confirmed him in the opinion that the best policy the Council could adopt in the field of fuel investigations was one of merely watching developments. Liquid fuel research is a particularly expensive matter, and being a world-wide problem is being energetically undertaken by many of the older countries having much more powerful research organizations than has Australia.

Second Meeting of Standing Committee on Agriculture.

The second meeting of the Standing Committee on Agriculture (see this *Journal,* Vol. I., No. 1, p. 58) was held in Melbourne on the 6th and 7th of March, 1928. Mr. G. L. Sutton and Professor T. G. B. Osborn were unable to attend, but the remainder of those present at the first meeting were also present at the second meeting. In addition, Professors E. J. Goddard, S. M. Wadham, and R. D. Watt, Dr. B. T. Dickson, and Mr. G. Lightfoot attended. The secretarial duties were undertaken by Dr. Jean White-Haney.

The more important matters dealt with were as follows:—

Imperial Agricultural Research Conference.—Dr. Cameron and Professor Richardson, two of the Commonwealth representatives, gave brief accounts of some of the more important matters discussed by the Conference and of the decisions reached. The full proceedings will be printed in England, and copies will be available in Australia. A brief report of the Conference was included in the last issue of the *Journal* (page 154).

Register of Agricultural Research.—The compilation of the Register of Agricultural Research Work in Progress throughout the Commonwealth at the end of 1927 has been completed. This work was carried out as a result of the decision of the Agricultural Conference held in Melbourne in March, 1927, that such a Register would be useful to both Commonwealth and State agricultural workers. Copies of the Register were distributed at the meeting. It was decided that supplementary statements revising the Register should be furnished from time to time.

Rice Investigations.—Consideration was given to the question as to whether certain rice investigations that had been suggested should be undertaken by the Council, or by the States interested. The particular investigations related to cultural problems connected with rice growing in Australia, and they were of such a nature that a solution could probably be obtained by means of tests similar to the tests carried out in regard to other cereals, such as wheat, at State Experimental Farms. It was resolved as follows:—

> "This Committee considers that the rice investigations suggested as being required come within the scope of State departmental functions under the agreement reached at the Agricultural Conference of March, 1927."

Demonstration Work.—In connexion with an urgent request made at a representative conference of dried fruit producers and others (which met in November, 1927), that the Council arrange for the officer in charge of its Viticultural Station, Merbein—Mr. A. V. Lyon—to visit some of the principal irrigation areas with a view to organizing demonstrations, a discussion arose as to whether it was appropriate for the Council rather than the States to undertake such work. It was decided that, if such questions arose in the future, it would be advisable to consult the State Departments concerned before final arrangements were made.

British Investigations on the Vitamin Content of Dairy Products.—A summary of a scheme suggested by Dr. S. S. Zilva, of the Lister Institute, London, concerning the vitamin contents of butter was read

and discussed. Dr. Zilva is anxious to obtain selected samples of butter from parts of Australia concerning which accurate records have been kept. It was considered that the experimental samples required could easily be prepared at the State farms of those States, viz., Victoria and Queensland, from which it was desired by Dr. Zilva that the samples should be obtained.

Sir John Russell's Visit to Australia.—It was reported that the Australian Universities had invited Sir John Russell, Director of Rothamsted Experimental Station, to visit the Commonwealth during 1928, and that the Council had been approached for suggestions as to the places of agricultural interest Sir John Russell should visit. It was decided that neither the Council nor the State Departments of Agriculture should suggest details until a general itinerary had been approved of by the University Extension Board, under whose auspices the visit is being made.

Agricultural Research Projects in Western Australia.—The Chief Executive Officer of the Council, Dr. Rivett, stated that he had recently returned from a visit to Western Australia, where he had discussed the matter of the policy of the Council best suited to Western Australian conditions. It had been arranged that the Council should assist with several important research projects, provided that the State Department provided adequate space, equipment, and facilities for the necessary workers.

Dairy Research.—The question of dairy research was discussed at length, and, while this matter was under review, Messrs. Rankin, Proud, and Osborne, of the Dairy Produce Control Board, and also Mr. Carroll, Supervisor of Dairy Exports, were present by invitation. This whole matter is referred to at length on page 207.

Department of Scientific and Industrial Research, New Zealand.

The New Zealand Department of Scientific and Industrial Research has recently issued its first three bulletins, and copies are now available in Australia.

Bulletin No. 1 deals with manurial experiments in the South Island of New Zealand, carried out previously to 1923. It is written by F. W. Hilgendorf, M.A., D.Sc., of Canterbury Agricultural College.

Bulletin No. 2 was written by M. J. Scott, B.A., B.Sc., A.I.C., of the Department of Animal Husbandry, Canterbury Agricultural College. It deals with pig production and the results of feeding trials.

Bulletin No. 3 consists of a report on the carbonization and briquetting of Waikato lignites by Sir Richard Redmayne, K.C.B., &c. Early in 1926, some 75 tons of slack coal from the mines of the Waikato District were consigned to Taucha, near Halle, in Saxony, for the purpose of investigating, firstly, its possibilities when submitted to distillation or low temperature carbonization processes, and, secondly, its use for the manufacture of briquettes. Sir Richard Redmayne was asked by the New Zealand Government to supervise the tests and furnish a report thereon.

Poison Plants: The Presence of Cyanogenetic Glucosides in Certain Species of Acacia.

By Horace Finnemore, B.Sc., F.I.C., (Lond), *and W. C. Gledhill.**

This note gives an account of the examination of some sixty species of *Acacia,* initiated with a view to ascertaining the cause of the death of a sheep which Dr. H. R. Seddon, Director, Glenfield Veterinary Research Institute, had fed with *Acacia glaucescens* Willd. (Coast Myall). It was found that both this and the nearly allied *A. Cheelii* Blakely and *A. Cunninghamii* (Bastard Myall) contain a cyanogenetic glucoside, as does also *A. doratoxylon.* In these plants the glucoside is not associated with an appropriate enzyme, so that there is no development of hydrocyanic (prussic) acid until an enzyme is added, emulsion of sweet almonds being used in some experiments, while it is found that a solution of buffalo grass also brings about the same result. *A. Cheelii* was fed to bullocks during the drought on the Upper Hunter in 1902. What amount of prussic acid these plants are capable of developing, and whether they are safe so long as the diet remains free from enzyme-containing material are problems remaining for investigation. Attention is also drawn to the list of 300 plants examined by Petrie, in over 200 of which, in deciding whether hydrocyanic acid was present, he relied on the presence in the plant of the enzyme capable of causing hydrolysis. The importance of specifying the season of the year at which material is collected is shown in the case of *Hakea dactlyoides,* which Petrie found to be free from hydrocyanic acid. The young brown leaves collected in the third week in December readily give hydrocyanic acid while last year's leaves seem to be entirely free from it.

Forest Products Research—Report by Mr. A. J. Gibson, I.F.S.

During the latter part of 1927, Mr. A. J. Gibson, F.C.H., F.L.S., F.Z.S., a senior officer of the Indian Forest Service visited Australia at the request of the Council, and on loan from the Government of India. After spending two or three months in visiting all the Australian States, inspecting the more important forestry areas and industries closely concerned with the utilization of forest products, and after considering research work in hand, and all the relevant literature that was available, Mr. Gibson furnished the Council with a detailed report on the whole question of forest products research in Australia.

A brief account of that report, which has just been received, is given in the following paragraphs. In his introductory remarks, the writer refers to the present lack of co-ordination and standardization in Australia. He is of the opinion that this can only be overcome by centralization of efforts in the field of scientific forestry, and research in forest utilization, and he mentions the earlier endeavours to create a Forest Products Laboratory in Western Australia. The scientific utilization of forest products is discussed at length, and the various products are treated separately. It is stated that the existing "rule-of-thumb" methods in Australia cause enormous waste, and, as a result, timber resources are not being efficiently conserved.

---

* Department of Pharmacy and Materia Medica, University of Sydney.

The commercialization of artificial seasoning would pay for itself handsomely. The existing air-seasoning processes tie up capital estimated in millions sterling per annum, and the interest on this alone would cover the cost of artificial seasoning and all necessary plant. Arguments against centralization of investigations on seasoning from the point of view of climatic variations, are dispelled by results already obtained in America relative to the "fibre saturation point." In addition, a study of microstructures in conjunction with seasoning would be highly informative, both for seasoning and growing studies, as well as providing a key to the hardwoods.

Utilization of lower-grade timbers for specific purposes, and economy of timber in general are just two of the objects of a thorough study of timber testing. Standardization of methods, publication of useful data, and compilation of tables for technical use, are also media whereby economy would result.

Apart from forest fires, probably the largest item of preventible waste is decay, of which the remedy is preservation. This is not the only advantage to be gained, for by a thorough study of the subject, less resistant timbers could be treated to replace the more useful hardwoods some of which are most valuable for cabinet and the finer structural uses. At present, there is an excessive demand on valuable woods, such as jarrah, for rough constructional work, and the elimination of such species is threatened. The development of softwood forests and a study of their preservation is indicated as a possible means towards the conservation of our hardwoods.

Investigations that have already been made on the production of wood pulp and tanning materials have been sufficiently successful to encourage the extension of such work. The economic utilization of "mill waste" is mentioned as a line along which investigations should also be made.

Some valuable essential oils are at present being won on a relatively small scale from Australian trees, and the extension of this industry depends on the scientific research which is conducted to show the way. The number of minor forest problems is large, and is certain to increase when a medium for attacking them is established. Existing methods of lumber utilization are by no means in keeping with a conservative policy of forest management, and immediate attention to this matter is required.

The writer stresses the need for close co-operation between the Forests Departments and any Forest Products Laboratory that may be established. He believes this co-operation would be achieved per medium of a suitably constituted Board of Forestry. He also is of the opinion that forest products research work should be centralized in Canberra.

For the most efficient results, he recommends the employment of experts to initiate research, and to train Australian workers. In a consideration of the design and cost of an Australian Forest Products Laboratory, he estimates that the initial outlay will involve £49,000, and with a personnel such as he suggests the annual cost, including maintenance, would be approximately £19,000.

In the conclusion to the report, it is stated that:—

"It is my firm conviction that Australia and Australians are destined to take a high place in the development of the British Empire. If they do not, it will not be the fault of the country and its vast actual and potential wealth, in which Australian forests are a significant item. If they do, her forests and the role to be played by her forests in this development will be appreciated at their right value. There is already a strong current of public opinion in favour of a more progressive forest policy, in which policy the fighting and prevention of bush fires is definitely the most important step. Public consciousness is also awakening to the fact that all is not well in regard to Australia's timber supplies. My report, and the experience of scientific workers in forest utilization throughout the world, show what has to be done. The doing of it, however, is the duty and responsibility of the representatives of the people—Australia's legislators."

Annual Report of the British Department of Scientific and Industrial Research.

The Twelfth Annual Report* of the British Department of Scientific and Industrial Research has just become available in Australia.

The main investigations of the Department are in the field of the secondary industries, the research needs of agriculture in Great Britain being looked after by separate funds controlled by the Development Commission. The extent of the Department's activities will be gauged from the fact that, during the current financial year, the Department estimates it will expend £451,951, as compared with a corresponding figure of £442,877 for the previous financial year. A few points of local interest have been drawn from the report, and are mentioned in the following paragraphs.

For some years, the Department has been making special maintenance grants to independent research students. It has recently made a review of what these allowances have accomplished, and has satisfied itself as to the value of the scheme. About one-third of those receiving grants ultimately find their way into industry. The opinion is expressed that despite the advances of the last few years, industrial scientific research and the employment of scientifically trained men is only at its beginning, and a very big expansion will have to take place if Great Britain is to improve on its position among the manufacturing nations of the world. Incidentally it has been found that the demand for first class students of chemistry does not fall short of the supply, and that it is rather the chemists who fail to reach the highest University standard, for whom there is little demand.

In addition to maintenance grants, the Department makes another kind of grant, the main object of which is not so much to produce scientists as to produce results. Several students were appointed, for instance, to work under Sir William Bragg on X-rays. These have since transferred to other institutions, with the result that a knowledge

* Report of the Committee of the Privy Council for Scientific and Industrial Research for the year 1926-27, Comd. 3002, H.M. Stationery Office, 1928.

of this fruitful method for determining the properties of materials has been spread throughout the country. A similar series of grants has recently been made for the purpose of training a band of workers in chemical reactions at very high pressures—another process with great industrial possibilities.

The amount of time and money (approximately £50,000 per annum) the Department has spent on the investigation of the low temperature distillation of coal is well known. That work is apparently coming to fruition, for it is stated in the report that the Gas Light and Coke Company, after an exhaustive survey of existing plant, has selected the experimental retorts developed at the Fuel Research Station as being the most promising type for the commercial trial of low-temperature carbonizing processes for use in conjunction with London gas works. A bank of these retorts, capable of producing 100 tons of smokeless fuel per day, is to be erected. Other work on fuels carried out by the Department has shown beyond doubt that a large proportion of coal substance can undoubtedly be converted into liquid fuels by means of the Bergius process. However, it is not yet possible to assess the value of these developments.

The Department has recently set up a Water Pollution Research Board, to undertake research on the prevention of the pollution of rivers and other sources of water supply, by industrial effluents and sewage. This action has become necessary owing to the rapidly improving modern standards of sanitation leading to a correspondingly rapidly increasing demand for pure water for domestic purposes.

During the year the Department published a pamphlet entitled *Co-operative Industrial Research**, which gave an account of the various co-operative research associations that have been formed in different industries.

The report contains a large mass of information regarding the other activities of the Department, e.g., in regard to food preservation, the National Physical Laboratory, the Building Research Board, the Forest Products Laboratory, &c., but for details of these the original publication should be consulted.

Industrial Research in the United States of America.

The National Industrial Conference Board of New York has recently made a survey of the research work in progress in the United States. It finds that about £40,000,000 is annually being spent on research by industrial corporations and by the Federal Government, the proportion of the contributions to this amount of the private interests mentioned to the contributions of the Government being as two is to one.

In the year 1921, only 578 companies maintained research departments or laboratories, but at the present time this number has grown to 1,000. In addition, 70 trade associations are spending about £3,000,000 per annum on research, and 152 colleges and technical schools about £300,000. Further, much technical investigational work is being

* *Co-operative Industrial Research.* An account of the work of Research Associations under the Government scheme, H.M. Stationery Office, 1927.

carried out in connexion with industrial production, the costs of which are not segregated as such, but are accounted for as part of production costs, and hence they are not included in the amounts mentioned above. The latter amounts are also not inclusive of other large sums made available by local and State Governments, nor do they include the expenditure of organizations specifically set up to undertake research work in a consultative capacity.

Some of the individual sums spent on research are large. For instance, one manufacturing company alone has spent as much as £1,000,000 and more in a single year, whilst a public utility corporation spent approximately £2,500,000. In general, manufacturing companies allocate from 1 to 3 per cent. of their gross returns to research purposes.

Murray River Valley: Conference *re* Future Policy.

Following on a report on the Australian dried fruits industry issued by the Development and Migration Commission, the Prime Minister recently convened a conference of representatives of organizations concerned in the development of the irrigation areas of the Murray River Valley.

This Conference met on the 27th and 28th of February. It recommended that an Advisory Committee, consisting of representatives of the various States, of the Department of Markets, and of the Development and Migration Commission be set up to collate existing information, to investigate market prospects in Australia and abroad, and to advise on co-ordinating production and future development.

It has been decided that the Committee will bring under the notice of the Council for Scientific and Industrial Research problems requiring scientific investigation.

Scientific Research in Italy.

It has been authoritatively reported that Premier Mussolini, the head of the Italian Government, has recently extended his whole-hearted financial and moral support to the National Research Council and its President, Signor Marconi. In addition, he has vested that Council with numerous and important responsibilities, which may be summarized as follows:—

(*a*) The institution and systematization of well-equipped research laboratories and museums with the co-operation of the laboratories of Italian Universities and other private experimental stations.

(*b*) The control of representation at international technological and scientific conferences.

(*c*) The regulation of scientific and technical congresses in Italy.

(*d*) The compilation and diffusion abroad of Italian technical-scientific bibliography to be aided by the co-operation of all State and public organizations.

(*e*) The establishment of an information bureau to make available data concerning scientific and technical results.

The Council, which came into existence in 1921, had not been in a position to achieve much of value. Now, with this new organization research will be conducted on a large scale. To aid the Council in its undertakings, a Board of Directors and ten national committees, one for each of the principal branches of science, have been established. Each Committee has its own Executive Board, consisting of a president, a secretary, and three other members. In addition, the National Board of Directors has the power to propose from time to time special national commissions to study specific problems.

Signor Marconi, associated with the leading Italian scientists, is now directing a technical inquiry into the national resources of the country. He expects to co-operate mainly with Great Britain, France, America, and Germany in this work.

The search for oil and coal deposits, chemical research in the field of coal, tar dyes, and fuels are some of the most outstanding problems which are being studied.

The Science and Industry Endowment Fund: Recent Grants.

Since the previous account of this fund was given,* the following actions have been taken:—

Grants of assistance of the order of £50 each have been made to Mr. H. B. Williamson for botanical field work; Mr. J. T. Jutson, B.Sc., LL.B., for physiographical work in the Port Phillip district; Miss I. C. Cookson, B.Sc., for geological investigations; Mr. A. H. S. Lucas, M.A., B.Sc., for botanical work in connexion with Australian seaweeds; Messrs. P. S. Allen, B.C.E., and A. R. Moon, B.A., B.C.E., for research on electric welding of joints in steel structures; Professor B. D. Steele, University of Queensland, for chemical research; Dr. T. G. H. Jones, University of Queensland for chemical research; Mr. J. G. Wood, B.Sc., Adelaide University, for research on plant physiology, &c.; Dr. W. Davies, Department of Chemistry, University of Melbourne, for chemical research; Dr. S. W. Pennycuick, Adelaide University, for chemical research; Mr. E. E. Kurth, University of Tasmania, for research on oil shales; Mr. H. R. Marston, Adelaide University, for biochemical research; Professor A. McAulay, University of Tasmania, for research on the corrosion of iron; Dr. J. R. Pound, School of Mines, Ballarat, for research on the properties of liquids.

* This journal, Vol. I., No. 2, p. 99.

The following additional appointments to Research Studentships have also been made:—

G. B. Tindale, B.Sc. Agr., a graduate of the University of Melbourne, left Melbourne last December, and proceeded to East Malling (Kent) Research Station to undergo one year's training in the investigation of fruit problems. During his absence, Mr. Tindale has been granted leave by the Department of Agriculture, Victoria, at which institution he was performing similar work.

S. A. Trout, M.Sc., a graduate (in chemistry) of the Queensland University. He will leave Australia in August next to undergo training in food preservation at the Low Temperature Research Station, Cambridge. Later, he will probably spend some months at the East Malling Research Station, and, later still, in South Africa. He will be abroad for two years.

Miss W. Kent-Hughes, B.Sc., a graduate of the Melbourne University. She will leave Australia at an early date to undergo special training in entomology in England. Her future plans will not be decided until she reaches England and meets Dr. Tillyard, who will have, by then, made arrangements for her training.

H. J. GREEN,
GOVERNMENT PRINTER,
MELBOURNE.